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United States
Department of
Agriculture

Forest
Service

**Engineering
Staff**

Washington, D.C.

EM-7720-100B

April 1985

Forest Service Specifications for Construction of Bridges & Other Major Drainage Structures

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PREFACE

The Forest Service, U.S. Department of Agriculture, developed this book for use in the preparation and administration of contracts for the construction of roads and bridges on the National Forest Development Road System under Public Works Contracts, or as a condition of Timber Sale Contracts.

This book contains the Standard Specifications that commonly apply in public works and timber sale contracts. When designated in a Forest Service contract, the specifications in this book are binding on the parties signing the contract and become a part of the contract. Provisions and clauses pertinent to Public Works Contracts are located in the Federal Acquisition Regulation (FAR) and the Department of Agriculture Acquisition Regulations (AGAR). Standard Provisions and Special Provisions for timber sale projects are located in the Timber Sale Contract, Divisions B (BT) and C (CT) respectively. Conditions and requirements peculiar to individual projects, including additions and revisions to Standard Specifications, are located in the Special Project Specifications section of the contract.

The Standard Specifications are generally presented in a format similar to "AASHTO Guide Specifications for Highway Construction" to encourage nationwide uniformity of specifications and contractual matters in highway construction.

This book is available to the public from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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SECTION 100–149 GENERAL SPECIFICATIONS

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Section 101 - Abbreviations

101.01
Organizations & Standards

Whenever in these specifications, or in other contract documents, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows. Reference to a specific standard or specification shall mean the latest edition or amendment in effect on date of invitation to bid.

AASHTO--American Association of State Highway and Transportation Officials

ACI--American Concrete Institute

AISC--American Institute of Steel Construction

AISI--American Iron and Steel Institute

AITC--American Institute of Timber Construction

ANSI--American National Standards Institute

APA--American Plywood Association

API--American Petroleum Institute

ASME--American Society of Mechanical Engineers

ASTM--American Society for Testing and Material

ATCC--American Type Culture Collection

AWPA--American Wood Preservers Association

AWPB--American Wood Preservers Bureau

AWS--American Welding Society

AWWA--American Water Works Association

CFR--Code of Federal Regulations

CRSI--Concrete Reinforcing Steel Institute

CS--Commercial Standard issued by U.S. Department of Commerce

DEMA--Diesel Engine Manufacturers Association

FAR--Federal Acquisition Regulation

FED SPEC. or FS--Federal Specifications

FSS--Federal Specifications and Standards

GSA--General Services Administration

MIL--Military Specifications

MSHA--Mine Safety and Health Administration

MUTCD--Manual on Uniform Traffic Control Devices

NBFU--National Board of Fire Underwriters

NBS--National Bureau of Standards

NEMA--National Electrical Manufacturers Association

NESC--National Electrical Safety Code

NFPA--(Fire)--National Fire Protection Association

NFPA--(Forest)--National Forest Products Association

NWMA--National Woodwork Manufacturers Association

OSHA--Occupational Safety and Health Administration

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.01

PCA--Portland Cement Association

PCI--Prestressed Concrete Institute

PS--Product Standard issued by the U.S. Department of Commerce

PTI--Post-Tensioning Institute

RIS--Redwood Inspection Service

SAE--Society of Automotive Engineers

SF--Standard Form

SSPC--Steel Structures Painting Council

UL--Underwriter's Laboratories, Inc.

USASI--United States of America Standards Institute

WCLIB--West Coast Lumber Inspection Bureau

WWPA--Western Wood Products Association

101.02
Pay Items
& Pay Units

	ABBREVIATIONS
Aluminum	AL.
Asphalt	ASP.
Barbed Wire	B.W.
Bituminous Coated Corrugated Steel Pipe	B.C.C.S.P. OR B.C.C.S. PIPE
Cement	CEMT.
Cement Treated	CEMT.-T.
Cement Treated Base	CTB
Clearing & Grubbing	CLEAR & GRUB
Compaction	CMPCT.
Concrete	CONC.
Corrugated Metal Pipe	CMP
Corrugated Steel Pipe	C.S.P.
Corrugated Steel Pipe Arch	C.S.P. ARCH
Cubic Yard	C.Y.
Cubic Yard Mile	C.Y.MI.
Diameter	DIA.
Each	EA.
Emulsified	EMLSFD.
Erosion and Pollution Control	E&P CONTROL
Fabricated	FABR.
Foundation	FOUND.
Furnished	FURN.
Gallon	GAL.
Grade	GR.
Height	HT.
High Strength	H. STRENGTH
Horizontal	HOR.
Hour	HR.
Linear Foot	L.F.
Liquid	LIQ.
Loading	LD.
Lump Sum	L.S.
Material	MAT'L
Maximum	MAX.
Method	M.

Mile	MI.
Minimum	MIN.
One Thousand Feet Board Measure	MFBM
One Thousand Gallons	M.GALS.
One Thousand Gallons Mile	M.GALS.MI.
One Thousand Square Feet	M.S.F.
Polyvinylchloride	PVC
Pounds	LBS.
Reflectorized	REFLECT.
Section	SEC.
Square Foot	S.F.
Square Yard	S.Y.
Station	STA.
Station Yard	STA. YD.
Strand	S.
Structural	STRUCT.
Structural Steel	S. STEEL
Stump	STMP
Target Value	TV
Thickness	TH.
Ton Mile	T.M.
Tops and Limbs	T&L
Utilization of Timber	UOT
Vertical	VERT.
White	WH.
Width	W.
With	W/
Without	W/O
Woven wire	W.W.
Yellow	YE.

Section 102 - Definitions

Wherever in these specifications, or in other contract documents, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

Adjustment in Contract Price. "Adjustment in contract price" shall mean "equitable adjustment" as used in the Federal Acquisition Regulations, or "Construction Cost Adjustment" as used in the Timber Sale Contract as applicable.

Arch Pipe. A culvert section, usually formed of bolted structural plates, that is an arc of a circle (usually one-half or less); that is, a bottomless culvert.

Base Course. The layer or layers of specified or selected material of designed thickness placed on a subbase or subgrade to support a surface course. (See figure 102-1.)

Bearings. The portion of a beam, girder, or truss that transmits the bridge superstructure load to the substructure.

Berm. Curb or dike constructed to control roadway runoff water. (See figure 102-1.)

Bridge. A structure, including supports, erected over a depression or an obstruction, such as water, road, trail, or railway, and having a floor for carrying traffic or other moving loads.

Bridge Length. The overall length measured along the centerline of road to the back of abutment backwalls, if present; otherwise, end to end of the bridge floor, but in no case less than the total clear opening of the structure.

Bridge Traveled Way Width. The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or, if curbs are not used, between the inner faces of parapet or railing.

Change. "Change" means "Change Order" as used in the Federal Acquisition Regulations, or "Design Change" as used in the Timber Sale Contract.

Clearing Limits. The limits of clearing as designated on the ground or on the drawings. (See figure 102-1.)

Conduit. A natural or artificial channel for carrying fluids, as water pipes, canals, and aqueducts.

Construction Slash. All vegetative material not meeting utilization standards, such as tops and limbs, timber, brush, and grubbed stumps associated with construction or reconstruction of a facility.

Contracting Officer (CO). The person with the authority to enter into, administer, and/or terminate contracts and make related determinations and findings.

Contractor. The individual, partnership, joint venture, or corporation undertaking the execution of the work under the terms of the contract and acting directly or through their agent, employees, or subcontractors. As used in specifications and drawings for specified roads (Timber Sale Contracts), "contractor" is "purchaser."

Controlled Felling. Directing the placement of trees in felling by wedges, jacks, cable tension, or distribution of holding wood or any combinations of these which will ensure that trees are dropped into previously cleared areas, or clear of any objects that are to remain.

Culvert. A conduit or passageway under a road, trail, or other obstruction. A culvert differs from a bridge in that it is usually constructed entirely below the elevation of the traveled way.

Cushion Material. Native or imported material generally placed over rocky sections of unsurfaced roads to provide a usable and maintainable traveled way.

Defect. A failure to meet a requirement with respect to a single quality characteristic.

Drawings. The documents, including plan and profile sheets, cross sections, diagrams, layouts, schematics, descriptive literature, illustrations, schedules, performance and test data, and similar materials showing details for construction of a facility.

Embankment. A structure of soil, aggregate, or rock material placed on the prepared ground surface and constructed to subgrade.

Engineer. The Contracting Officer's Representative (COR) or Engineering Representative (ER) responsible for onsite administration of the contract.

Equipment. All machinery and equipment, together with the necessary supplies for upkeep and maintenance, as well as tools and apparatus necessary for the proper construction and acceptable completion of the work.

Excess Excavation. Material from the roadway in excess of that needed for construction of designed roadways.

Forest Service. The United States of America, acting through the Forest Service, U.S. Department of Agriculture.

Gauge. The term "gauge" when used in connection with the measurement of plates will mean the U.S. Standard Gauge, except when reference is made to the measurement of metal sheets used in the manufacture of corrugated metal, pipe, metal plate culverts and arches, and metal cribbing, then the term means the "gauge" or "thickness" specified in AASHTO M 36, M 167, M 196, and M 219, as applicable. When the term "gauge" refers to the measurement of wire, it will mean the wire gauge specified in AASHTO M 32.

Government Land. National Forest System lands, and other lands controlled or administered by the Forest Service or by other Federal agencies.

Inspector. The Government-authorized representative designated in writing by the CO, COR, or ER responsible for detailed inspection.

Job-Mix Formula. The percentage of each material in a mixture intended for a particular use.

Laboratory. A testing laboratory of the Government or any other testing laboratory approved by the Contracting Officer.

Materials. Any substance specified for use in the construction of the project and its appurtenances.

Maximum Density. The highest density that can be obtained under stated conditions.

Measurement. Determining and expressing the quantities of work or materials.

Multi-Beam Girder. A precast, prestressed concrete member where the concrete deck is precast as an integral part of the member.

Neat Line. A line defining the proposed or specified limits of an excavation or structure.

Nominal Dimensions or Weights. The numerical values shown on the drawings or in the specifications as measurements of material to be used in the construction.

Nominal Maximum Particle Size. The largest sieve size listed in the applicable specification upon which any material is permitted to be retained.

Overbreak. Material beyond the neat line of an excavation that is removed in the process of excavation, usually by blasting.

Pavement Structure. Subbase, base, or surface course, or combination thereof, placed on a subgrade to support the traffic load and distribute it to the roadbed.

Pioneer Road. Temporary construction access built along the route of the project.

Pipe. A culvert that is circular (round) in cross-section.

Pipe-Arch. A pipe that has been factory-deformed from a circular shape such that the width (or span) is larger than the vertical dimension (or rise).

Profile Grade. The trace of a vertical plane, as shown on the drawings, intersecting the top surface at the centerline of the proposed facility construction.

Purchaser. The individual, partnership, joint venture, or corporation contracting with the Government under the terms of a Timber Sale Contract and acting independently or through his, their, or its agents, employees, or subcontractors.

Random Sampling. Sampling at times or locations determined in advance by the use of a table of random numbers.

Reasonably Close Conformity. Unless working tolerances are specified, all work performed and materials furnished shall be in reasonably close conformity with lines, grades, cross sections, dimensions, and material requirements shown on the drawings, indicated in the specifications, or designated on the ground. "Reasonably close conformity" is compliance with reasonable and customary manufacturing and construction tolerances.

Right-of-Way. A general term denoting (1) the privilege to pass over land in some particular line (including easement, lease, permit, or license to occupy, use, or traverse public or private lands) or (2) land, appurtenances thereto, or interest therein, usually in a strip, acquired for public or private passageway. (See figure 102-1.)

Road Template. The shape and cross-sectional dimensions of the roadway to be constructed as defined by the construction staking notes and the characteristics of the typical sections.

Roadbed. The graded portion of a road between the intersection of subgrade and side slopes excluding that portion of the ditch below subgrade. (See figure 102-1.)

Roadside. A general term denoting the area adjoining the outer edge of the roadway. (See figure 102-1.)

Roadway. The portion of the road within the limits of excavation and embankment, including slope rounding. (See figure 102-1.)

Schedule of Items. A schedule in the contract that contains a listing and description of construction items, quantities, units of measure, methods of measurement, unit price, and amount.

Second Samples. A sample taken when the initial sample indicates that the material is defective.

Shoulder. The portion of the roadway contiguous to the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of pavement structure. (See figure 102-1.)

Sidewalk. The portion of the roadway constructed primarily for pedestrian use.

Special Project Specifications. The specifications that detail the conditions and requirements peculiar to the individual project, including additions and revisions to Standard Specifications.

Specifications. A description of the technical requirements for a material, product, or service that includes criteria for determination whether these requirements are met.

Standard Specifications. Specifications approved for general application and repetitive use.

Subbase. The layers of specified or selected material of designed thickness placed on a subgrade to support a base course.

Subgrade Treatment. Modification of roadbed material by stabilization.

Subgrade. The layers of roadbed that bring it up to the top surface, upon which subbase, base, or surface course is constructed. For roads without base course or surface course, that portion of roadbed prepared as the finished wearing surface. (See figure 102-1.)

Substructure (Bridge). All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the backwalls, wingwalls, and wing protection railings.

Superstructure (Bridge). The entire structure except the substructure.

Surface Course. The top layer of a pavement structure, sometimes called the wearing course, usually designed to resist skidding, traffic abrasion, and the disintegrating effects of climate. (See figure 102-1.)

Tackifier. Binder for vegetative mulch.

Target Value. The percentage of each material in a mixture intended for a particular use from which allowable variations are measured.

Timber Sale Contract. A written contract for the removal of National Forest timber.

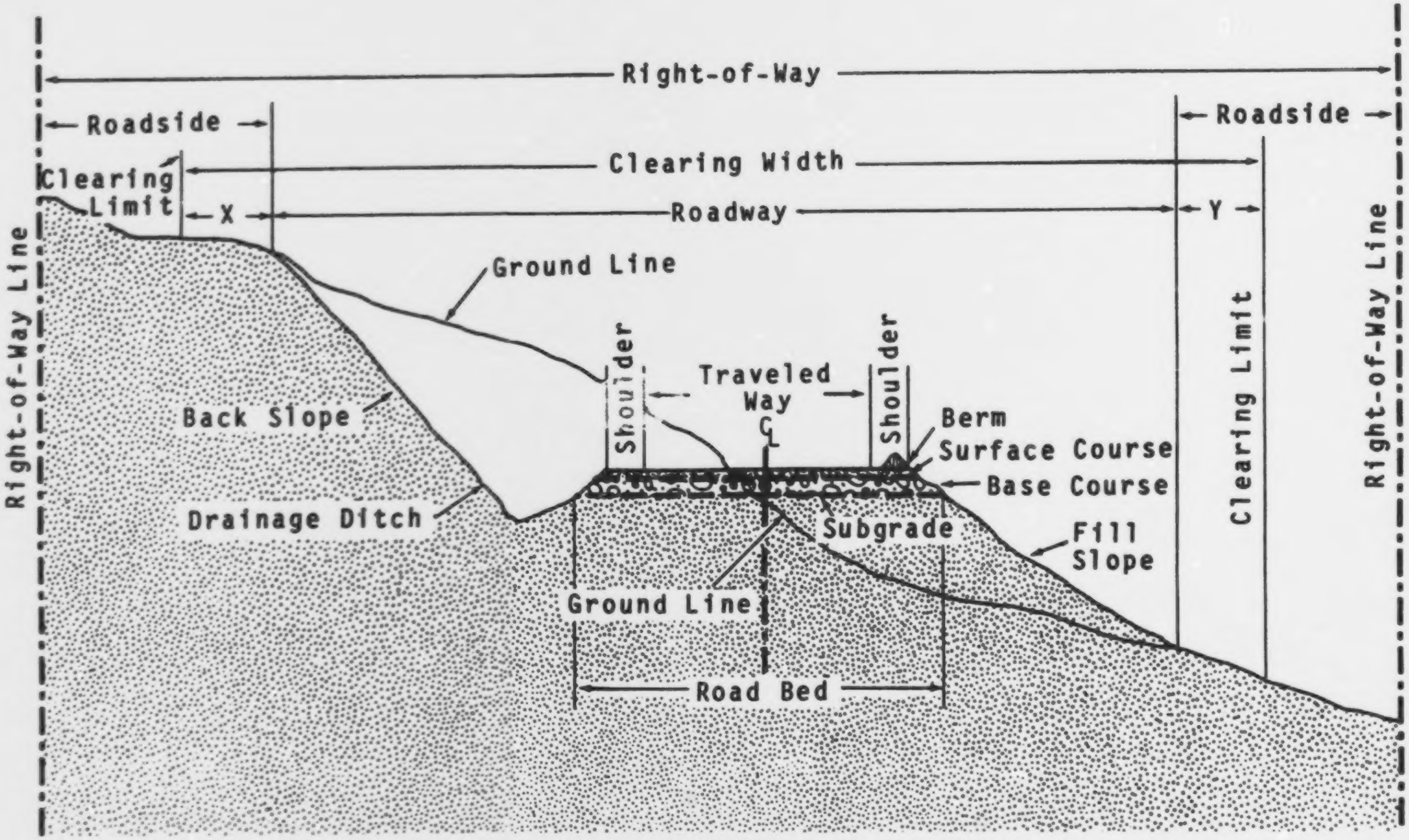
Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes. (See figure 102-1.)

Turnout. A short auxiliary lane on a one-lane road provided for the passage of meeting vehicles.

Unit of Measurement. The unit and fractions of units shown in the Schedule of Items.

Unsuitable Material. The material excavated during roadway construction that is not usable in embankment and must be disposed of or that can be used only in certain locations or for limited purposes.

Utilization Standards. The minimum size and percent soundness of trees described in the specifications to determine merchantable timber.


Right-of-Way
Roadside
Roadside
Clearing Width
Clearing Limit
X
Roadway
Y
Ground Line
Right-of-Way Line
Right-of-Way Line
Clearing Limit
Shoulder
Traveled Way
Shoulder
Berm
Surface Course
Base Course
Back Slope
CL
Drainage Ditch
Subgrade
Fill Slope
Ground Line
Road Bed

Note: Shapes and dimensions will vary to fit local conditions.
See drawings for typical sections.
X and Y denote clearing outside of roadway.

Figure 102-1.--Illustration of road structure terms.

Section 103 - Intent of Contract

103 The intent of the contract is to provide for the complete construction of the project described in the contract. Unless otherwise provided, the contractor shall furnish all labor, materials, equipment, tools, transportation, and supplies, and shall perform all work required to complete the project reasonably close conformity with drawings and specifications, and in accordance with provisions of the contract.

Section 104 - Maintenance for Traffic

104.01 Roads To Be Constructed

Unless otherwise provided in the SPECIAL PROJECT SPECIFICATIONS, existing roads, while undergoing improvement, shall be kept open to all traffic by the contractor and maintained in a condition that will adequately accommodate traffic. No work that interferes or conflicts with traffic or existing access to the roadway surface shall be performed until a plan for the satisfactory handling of traffic has been submitted by the contractor and approved by the Engineer. Specific requirements for temporary closures, detours, part-width construction and access to adjacent or intersecting facilities will be SHOWN ON THE DRAWINGS or described in SPECIAL PROJECT SPECIFICATIONS. Construction signing for traffic control shall conform to the Manual on Uniform Traffic Control Devices (MUTCD).

Prior to the contractor shutting down any operations, the contractor shall take such precautions as may be necessary to prevent damage to the project, such as temporary detours, approaches, crossings or intersections; and shall make provisions for normal drainage and minimization of erosion. All travelways shall be left in a condition suitable for traffic.

The Government may permit use of portions of the project during periods that the contractor has shut down operations. All maintenance attributable to permitted use during periods of work suspension will be provided by the Government unless the maintenance results from fault or negligence of the contractor. Any maintenance not attributable to use, or necessary during suspensions resulting from fault or negligence of the contractor, shall be the contractor's responsibility.

104.02 Use of Roads by Contractor

The contractor is authorized to use Forest Service roads for all activities necessary for completion of this contract subject to the limitations and authorizations described in SPECIAL PROJECT SPECIFICATIONS, when such use will not cause damage to the roads or National Forest resources and when traffic can be accommodated safely.

105.01 Handling Materials

All materials shall be transported and handled to preserve their quality and fitness for the work. Aggregates shall be stockpiled, loaded, and transported in a manner that will preserve specified gradation and avoid contamination. Stockpiles of aggregate having different gradations shall not be intermingled.

105.02 Weighing Devices

When the measurement is by weight, the contractor shall provide weigh scales, and shall transport the materials so they can be weighed. All weighing shall be done by the contractor.

(a) Platform Scales. Platform scales shall be of sufficient length and capacity to permit simultaneous weighing of all axle loads of each hauling unit.

The scales shall be accurate to within 1 percent of the correct weight throughout the range of use. Before using the scales and as frequently thereafter as the Engineer determines necessary to ensure accuracy, the contractor shall have the scales checked, adjusted, and certified by a representative of the State agency responsible for weights and measures or by a qualified manufacturer's representative. The contractor shall maintain the scales to the required accuracy.

The contractor shall provide the Government with copies of weight tickets from a certified scale.

The contractor may have the material weighed on other certified scales without additional compensation and shall furnish certified weight tickets for all material delivered to the project. The contractor shall guarantee permission for a Government representative to periodically check the weighing procedure and records.

(b) Belt Conveyor Scales. Belt conveyor weighing will be accepted in lieu of platform scales, provided this method or device meets the requirements specified below and is compatible with the provisions of measurement and payment in the applicable specifications.

The belt conveyor scale shall meet the design, marking, installation, and tolerance requirements of the National Bureau of Standards Handbook No. 44, and shall be certified by a copy of a National Bureau of Standards Prototype Examination Report of Test.

The weighing mechanism shall contain a weight totalizer and a self-printing device that legibly imprints the load-out weight on appropriate serially numbered and time-dated tickets. The time dating may be done either by an automatic printing device or manually. Each ticket shall be delivered to the Government representative at job site or point of use. The totalizer calibration adjustment and ticket imprinter shall be furnished with a security lock and key.

Under observation of the Engineer or of a designated Government representative, the contractor shall run a daily zero-load test in accordance with National Bureau of Standards Handbook No. 44.

105.03 Sampling & Testing

For contractor-furnished sources (see Section 105.06), the contractor shall submit test results and a Certificate of Compliance that states that the aggregate meets the contract requirements. For designated sources (see Section 105.06), the contractor shall submit test results for aggregate gradation and a Certificate of Compliance that states gradation meets contract requirements. Crushing, screening, and mixing plants shall be equipped with sampling devices. The contractor shall take additional samples as required to validate the certification.

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Sampling and testing of the material before incorporation into the work shall be in accordance with AASHTO requirements and shall occur as follows:

(a) For onsite produced materials at crushing or screening plants: after additions of any necessary blending material.

(b) For commercially produced aggregates: at the producer's plant or stockpile.

(c) For gradation of combined aggregate in bituminous plant mixtures: either before or after introduction of bituminous material.

These test results shall not preclude later sampling and testing for final acceptance after final processing of the material.

105.04
Certification & Sampling of Bituminous Materials

(a) Certification with Shipments. When each load of bituminous material is delivered, the contractor shall furnish the Engineer with one copy of the Bill of Lading and a fully executed Certificate of Compliance conforming to the format below (see figure 105-1). A separate Certificate of Compliance will not be required if the standard Bill of Lading contains the essential information required by the certificate.

(b) Sampling. Sampling of bituminous material may be required to validate certifications furnished by the contractor. When sampling is directed by the Government, the actual samples shall be obtained by the contractor in the presence of the Engineer. All delivery and plant equipment shall be constructed to permit sampling in conformance with AASHTO T 40 test procedure.

Consignee ______________________ Designation ______________________
Contract Number ______________________ Date ______________________
Identification (truck no., car no., etc. ______________________
Type and Grade ______________ With Additive (percent and brand) ______________
Loading Temp. ______________ Net Weight ______________________
Net Gallons ______________ Specific Gravity ______________________

This shipment of bituminous material identified above and covered by this Bill of Lading complies with Forest Service STANDARD SPECIFICATIONS as modified by SPECIAL PROJECT SPECIFICATIONS applicable to this project.

Producer ______________________
Signed ______________________
Producer's Representative

Figure 105-1.--Sample Bill of Lading and Certificate of Compliance.

105.05
Rights in & Use of Materials Found or Produced on the Work

(a) The contractor, with the written approval of the Contracting Officer, may use on the project suitable stone, gravel, sand, or other material found in the excavation. Payment will be made both for the excavation of such materials at the corresponding contract unit price and for the pay items for which the excavated material is used. The contractor shall replace, without additional compensation, sufficient suitable materials to complete the portion of the work that was originally contemplated to be constructed with such material.

(b) Materials produced or processed from Government lands in excess of the quantities required for performance of this contract are the property of the Government. The Government is not obligated to reimburse the contractor for the cost of their production.

105.06 Material Sources

105 .06

(a) Designated Sources. Sources of local materials designated in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS are guaranteed by the Government for the quality and quantity of material in the source. The contractor shall determine the equipment and work required to produce the specified product. The contractor shall submit test results and a Certificate of Compliance that states that the gradation of the aggregate meets the contract requirements.

The contractor shall utilize all suitable material in the source. The designation of a source will include the right of the contractor to use areas SHOWN ON DRAWINGS for the purposes designated (that is, plant sites, stockpiles, haul roads). Unless otherwise indicated or approved, no additional operating area will be allowed, and the contractor will be required to operate in the confines of the area(s) designated.

The weight/volume relationship used for determination of designed quantities of material in designated sources subject to weight measurement are SHOWN ON THE DRAWINGS.

Should the designated source, due to causes beyond the control of the contractor, contain insufficient suitable material, the Government will provide another source with an adjustment in contract price.

(b) Contractor-Furnished Sources. When the material sources are not designated as provided above, or the contractor elects not to use designated sources, the contractor shall be responsible for furnishing material that produces an end product equivalent in performance to that originally designated. An adjustment in contract price will be made where the weight/volume relationship differences between designated source material and contractor-furnished source material results in a financial disadvantage to the Government. The contractor shall be responsible for completing any pit development specified for a designated source, even though the contractor does not choose to obtain material from the source if such a statement is SHOWN ON THE DRAWINGS.

Quality testing in conformance with applicable requirements and acceptable to the Engineer to establish the equivalency of the end product shall be the responsibility of the contractor. Test results shall be furnished to the Engineer.

Section 106 - Measurement & Payment

106.01 Measurement & Payment

Measurement and payment for contract work will be made only for and under those pay items included in the SCHEDULE OF ITEMS. All other work and materials will be considered as included in the payment for items shown.

When more than one class, size, or thickness is specified in the SCHEDULE OF ITEMS for any pay item, suffixes will be added to the item number to differentiate between the items.

106.02 Determination of Quantities

The following measurements and calculations are used to determine contract quantities.

For individual construction items, longitudinal and lateral measurements for area computations will be made horizontally or corrected to horizontal measurement unless otherwise specified. Measurements for seeding, mulching, geotextiles, netting, erosion control blankets, and sodding will be along slope lines.

The average end area method will be used to compute volumes of excavation or embankment. However, if in the judgment of the Engineer, the average end area method is impractical, measurement will be made by volume in hauling vehicles or by other three dimensional methods.

Structures will be measured according to neat lines SHOWN ON THE DRAWINGS or as altered by the Engineer in writing to fit field conditions.

For items that are measured by the linear foot, such as pipe culverts, fencing, guardrail, and underdrains, measurements will be made parallel to the base or foundation upon which the structures are placed. Pipe and pipe arch culverts shall be measured along center of invert and arches shall be measured at spring line.

For aggregates weighed for payment, the tonnage will not be adjusted for moisture content, unless otherwise provided in SPECIAL PROJECT SPECIFICATIONS.

For bituminous material, volumes will be measured at 60 °F or will be corrected to the volume at 60 °F by using ASTM D 1250 for asphalts. Emulsified asphalt will be measured at 60 °F or measured by converting the gallonage at another temperature to gallonage at 60 °F by means of the following formula:

$$\text{Gallons at } 60\ ^\circ F = \frac{\text{Gallons at } A\ ^\circ F}{1 + 0.00025\ (A\ ^\circ F - 60\ ^\circ F)}$$

in which A °F is the Fahrenheit temperature of the material at the time the gallonage is measured.

For vehicular shipments, net certified scale weights or weights based on certified volumes will be used as a basis of measurement. Measurements will be adjusted when bituminous material has been lost from the vehicle or from the distributor, has been wasted, or has otherwise not been incorporated into the work. Determining true weights of hauling vehicles shall be made by weighing the empty vehicles at least once a day at the times the Engineer directs. Each vehicle shall bear a plainly legible identification mark.

When bituminous materials are shipped, net certified weights, or volume corrected for loss of foaming, can be used for computing quantities.

For standard manufactured items--such as fence, wire, plates, rolled shapes, pipe conduits--identified by gauge, weight, section dimensions, and so forth, such identifications shall be considered the nominal weights or dimensions. Unless controlled by tolerances in cited specifications, manufacturer's tolerances will be accepted.

106.03 Units of Measurement

Payment will be by units defined and determined according to U.S. Standard measure and by the following:

(a) Cubic Yard. A measurement computed by one of the following methods:

(1) Excavation, Embankment, or Borrow. The measurement computed by the average end area method from measurements made longitudinally along a centerline or reference line.

(2) Material in Place or Stockpile. The measurement computed using the dimensions of the in-place material.

(3) Material in the Delivery Vehicle. The measurement computed using measurements of material in the hauling vehicles at the point of delivery. Vehicles shall be loaded to at least their water level capacity. Leveling of the loads may be required when vehicles arrive at the delivery point.

(b) Cubic Yard Mile. A combination of linear and volumetric measurement meaning the movement of a cubic yard of material 1 mile.

(c) Each. One complete unit, which may consist of one or more parts.

(d) MFBM. One thousand feet board measure based on nominal widths, thicknesses, and extreme usable length of each piece of lumber or timber actually incorporated in the job.

(e) Station. One hundred linear feet measured horizontally.

(f) Station Yard. A combination of linear and volmetric measurement meaning the movement of a cubic yard of material one station.

(g) Thousand Gallons Mile. A combination of linear and volumetric measurement meaning the movement of 1,000 gallons of material 1 mile.

(h) Ton. Short ton consisting of 2,000 pounds.

(i) Ton Mile. A combination of linear and weight measurement meaning the movement of 1 ton of material 1 mile.

106.04 Methods of Measurement

One of the following methods of measurement for determining final payment is DESIGNATED on the SCHEDULE OF ITEMS for each pay item:

(a) Designed Quantities (DQ). These quantities denote the final number or units to be paid for under the terms of the contract. They are based upon the original design data available prior to advertising the project. Original design data include the preliminary survey information, design assumptions, calculations, drawings, and the presentation in the contract. Changes in the number of units SHOWN in the SCHEDULE OF ITEMS may be authorized under any of the following conditions:

(1) As a result of changes in the work authorized by the Contracting Officer.

(2) As a result of the Contracting Officer determining that errors exist in the original design that cause a pay item quantity to change by 15 percent or more.

(3) As a result of the contractor submitting to the Contracting Officer a written request showing evidence of errors in the original design that cause a pay item quantity to change by 15 percent or more. The evidence must be verifiable and consist of calculations, drawings, or other data that show how the designed quantity is believed to be in error.

(b) Staked Quantities (SQ). These quantities are determined from staked measurements prior to construction.

(c) Actual Quantities (AQ). These quantities are determined from measurements of completed work.

(d) Vehicle Quantities (VQ). These quantities are measured or weighed in hauling vehicles.

(e) Lump Sum Quantities (LSQ). These quantities denote one complete unit of work as required by or described in the contract, including necessary materials, equipment, and labor to complete the job. They will not be measured.

106.05
Price Adjustment for Out-of-Specification Bituminous Materials

Bituminous materials are defined as all types and grades of asphalt cement, liquid asphalt, emulsified asphalt, and dust oil.

If bituminous material fails one or more test requirements, and the Contracting Officer determines it is in the public interest to accept the material at a reduced price, the price reduction shall be based on the test results giving the largest percent price adjustment. The contractor may remove and replace the defective material or accept the adjustment.

The price reduction shall apply to all pay items affected.

Price adjustment will be based on samples taken in duplicate in accordance with AASHTO T 40 under the supervision of the Engineer. Samples shall be sent to an authorized laboratory. The laboratory shall test one of each duplicate sample and retain the other. When any test result is not within the specification limits, the laboratory shall immediately notify the supplier and the Engineer. The Engineer will then authorize check testing of the retained sample.

If the retained sample tests satisfactorily, the material will be accepted. If the retained sample also fails, the following schedule of price adjustments shall apply. The average of test values for the two samples will determine the basis for price adjustment, except when test results on the samples differ by more than the applicable AASHTO or ASTM Repeatability Unit; then, the test result numerically nearest the specification requirement will be used. (A repeatability unit is defined as D2S or D2S% limit for single operator precision described in ASTM recommended practice C 670.)

The schedule of price adjustments shall not apply to the following tests:

Test	AASHTO Test Method
Spot Test	T 102
Particle Charge	T 59
Ductility	T 51

Bituminous materials failing to meet specifications for these tests shall be removed and replaced.

See Table 106-1 for the schedule of price adjustments for bituminous materials that do not meet specifications.

Table 106-1.--Schedule of price adjustments for out-of-specification bituminous materials.

Application	Deviation from Specification Limit Measured in Reproducibility Units[a]			
	Less than 1	1, but less than 2	2, but less than 3	3 or greater
Price reduction applicable to bituminous base course and pavement mixture or to seal coat and bituminous surface treatment aggregate.	0%	5%	25%	Remove & Replace
Price reduction applicable to bituminous material paid for as a separate item.	0%	10%	25%	Remove & Replace

[a] A reproducibility unit is defined as D2S or D2S% limit for multi-laboratory precision described in ASTM recommended practice C 670.

The Sieve Test (AASHTO T59) results may be exempt from the schedule of price adjustments provided the contractor's quality assurance program includes checking the uniformity of bituminous spread rates in increments no greater than 1 foot over the width of the spray bar and variation between increments is no greater than 5 percent.

106.06
Earthwork Tolerances

Adjustments of horizontal or vertical alignment, within the tolerances specified in this contract, or shifts of balance points up to 100 feet shall be made by the contractor as necessary to produce the designed roadway section and to balance earthwork. Such adjustments shall not be considered as "Changes."

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199

SECTION 150–199 ENGINEERING

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Section 160 - Quality Control & Quantity Measurement

DESCRIPTION

160.01
Work

This work shall consist of providing quality control in conformance with the Inspection of Construction provisions of this contract to ensure compliance with the drawings, specifications, and provisions of the contract, and measuring the quantities of completed work in conformance with the provisions of the applicable specification. The contractor shall provide all personnel, equipment, tests, and reports necessary to meet the requirements of this specification.

CONSTRUCTION

160.02
Quality Control & Quantity Measurement System

The contractor shall provide and maintain a quality control system that will ensure that all services, supplies, and construction required under this contract conform to the contract requirements. The contractor shall perform, or cause to be performed, the sampling, inspection, and testing required to substantiate that all supplies, services, and construction conform to the contract requirements.

The contractor shall also perform, or cause to be performed, all measurement of quantities of materials incorporated into the work or work processes that are to be measured under the provisions of the contract.

(a) Quality Control Plan. The contractor shall submit in writing the following:

(1) Authorities and responsibilities of inspection and testing personnel.

(2) Experience and qualifications of inspection and testing personnel to be assigned and name and location of any (for hire) testing facility to be used.

(b) Approval of Quality Control Plan. The contractor's proposed quality control plan for all items requiring quality control shall be submitted to the Engineer for review prior to the contractor commencing work. Within 5 days of receipt of plan, the Engineer shall notify the contractor whether the plan adequately covers quality control requirements. Construction work shall not be performed prior to contractor's receipt of written approval of the proposed plan. The contractor shall submit to the Engineer, in writing, any proposed changes in the approved quality control plan. Proposed changes shall not be put into effect until approved in writing by the Engineer.

160.03
Sampling, Testing, Inspection, & Measurement of Quantities

The contractor shall provide and maintain appropriate measuring and testing devices, equipment, and supplies to accomplish the required measurement, testing, and inspection in a timely manner. Tests, measurements, and certifications shall be made as required by the drawings and specifications. The contractor shall take samples and perform inspections and tests necessary to achieve the quality of construction required by the contract and make required measurements of work under this contract performed onsite or offsite. Sampling and testing frequency for specific items shall be SHOWN ON THE DRAWINGS or in a SPECIAL PROJECT SPECIFICATION.

160.04
Records of Inspection, Tests, & Measurement

(a) Inspection and Tests. The contractor shall maintain current records of all inspections and tests performed. The following format or one containing the following information will be acceptable to the Government:

Road No.____________________ Contract No.__________________

Pay Item No.	Test	Date	Station	Standard	Results	Test By (Initials)

The contract shall certify in writing that all inspections and tests were performed in accordance with specifications.

(b) As-built Drawings. The contractor shall maintain a set of the contract drawings depicting as-built conditions. These drawings shall be maintained in a current condition and shall be available for review. All variations from contract drawings shall be indicated in red on the drawings. Upon completion of the contract work, as-built drawings shall be submitted to the Engineer.

160.05 Certifications & Measurements

(a) Offsite Produced Materials. The contractor shall furnish certificates executed by the manufacturer, supplier, or vendor, stipulating that all offsite produced materials incorporated into the work meet the applicable requirements SHOWN ON THE DRAWINGS or stated in the specifications. Incidental purchases needed to remedy minor shortages of material shall be certified by the contractor.

(b) Quantity Measurements. The contractor shall make all measurements for computation of quantities for all work items except those specified for payment by Designed Quantity (DQ). The contractor shall compute the quantities for periodic progress payments; the Engineer will compute the quantities for the final payment based on measurements taken by the contractor. All contractor measurements are subject to verification. The contractor shall submit all field notes, calculation sheets, and other data used to determine quantities. The contractor shall certify in writing as to the accuracy of the measurements and computations submitted.

The following format or one containing the following information will be acceptable to the Government:

Road No.____________________ Contract No.________________

Pay Item No.	Date	Station	Quantity or Measurement	Measured By (Initials)

MEASUREMENT

160.06 Method

There will be no separate measurement for this section.

PAYMENT

160.07 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS. Otherwise, quality control and quantity measurement shall be incidental to other specified work.

Payment will be prorated on the percentage of work accomplished on the related pay item that meets specifications.

Section 170 - Construction Staking, Transit L-Line

DESCRIPTION

170.01 Work

This work shall consist of the construction staking of a road project by the Transit L-line method in accordance with the drawings and specifications. The work includes furnishing all labor, equipment, instruments, materials, transportation, and other incidentals necessary to complete the construction staking in accordance with these specifications and acceptable engineering practice. The work shall also include setting grade-finishing stakes and staking major structures when required.

Construction staking shall be accomplished under the direction of a registered professional engineer or land surveyor. The professional engineer or land surveyor will be closely associated and familiar with the construction staking; periodic visits to the project site are required.

MATERIALS

170.02 Stakes

All stakes shall have the nominal dimensions SHOWN ON THE DRAWINGS or stated in the SPECIAL PROJECT SPECIFICATIONS. Identification stakes and hubs shall be of sufficient length to provide a solid set in the ground and to provide space for marking above ground when applicable. Other dimensions and materials may be used, such as steel reinforcing bars, wire flagging and markers, and metal pins, if approved in writing by the Engineer. The top 2 inches of all slope, guard, reference, clearing, and structure stakes shall be painted or marked with plastic flagging. Colors used on stakes or for flagging shall be as SHOWN ON THE DRAWINGS or stated in SPECIAL PROJECT SPECIFICATIONS.

170.03 Survey Note Paper & Books

Paper for survey notes shall be moisture-resistant paper. Notes shall be contained in books with covers that will protect the contents and retain the pages in numerical sequence during field use. Field notebooks or note paper shall be furnished by the contractor.

170.04 Government Furnished Documents

The contractor will be furnished drawings, P-line survey notes, P-line to L-line offset data, construction staking notes, and the projected locations of catch points. One set of "as staked" drawings and all documents shall be returned to the Engineer.

SURVEY REQUIREMENTS

170.05 Precision

Precision and accuracy requirements are contained in tables 170-1 and 170-2. All work performed under this specification shall meet the precision requirements DESIGNATED in the SCHEDULE OF ITEMS or stated in the SPECIAL PROJECT SPECIFICATIONS.

170.06 Survey Notes

All notes shall become the property of the Forest Service. Slope stakes note format shall conform to that shown in figure 170-2. Other formats may be used if approved by the Engineer.

Manually recorded survey notes shall be printed in characters at least 0.15 inches high and shall be legible at a distance of 2.5 feet. Errors shall be deleted by lining out. Date, crew names and positions, instrumentation, and weather shall be recorded in the notes at the beginning of each day's work. The party chief shall sign or initial each page of the notes immediately after the last entry for each day's work.

Electronically recorded survey notes shall be consecutively numbered and headed to identify the contents. The notes shall be supported and accompanied by a bound Day Book that records the project name and for each day identifies date, crew names and positions, instrumentation, weather, type of survey, stationing of sections between which survey was performed, and survey data or sketches that cannot be electronically recorded. The party chief shall sign or initial the electronically recorded notes and Day Book immediately after the last entry for each day's work.

170.07 Preliminary Survey Line

A preliminary survey line has been established on the ground for this project with initial and specific succeeding survey points referenced. The contractor shall reestablish missing P-line points necessary to control subsequent construction staking operations to the precision designated in the SCHEDULE OF ITEMS, SHOWN ON THE DRAWINGS, or stated in the SPECIAL PROJECT SPECIFICATIONS.

170.08 Establishing Centerline

The contractor shall determine the direction of centerline (L-line) tangents by coordinate ties furnished by the Forest Service. At least two points shall be located on each tangent to establish the direction of each tangent. The location of tangent lines established on the ground shall not be changed.

The deflection angle from one tangent to another shall be measured. When the measured deflection angle differs from the one SHOWN ON THE DRAWINGS, the measured angle and the curve external (E) SHOWN ON THE DRAWINGS shall be used to compute new curve data. The new curve data shall be computed and noted in the field books, and on the "as staked" drawings. The new control points (P.I., or P.C.'s & P.T.'s) shall be established on the ground using hubs and tacks.

Stationing of centerline points shall be established by horizontal distance measurements and staked to the nearest 0.01 foot for control points and 0.1 foot for other points continuously throughout the project. Equations shall be introduced at the P.T. of curves to adjust field stationing to that SHOWN ON THE DRAWINGS when the difference between designed and located centerline stationing exceeds 5 feet. Centerline stakes shall be set at even 100-foot and 50-foot stations when practicable, at significant breaks in the ground, at culvert locations, at station equation points, or other stations indicated in the staking notes. Stakes shall not be more than 50 feet apart. Curves of 20 degrees or more shall be staked every 25 feet. All other curves shall be staked every 50 feet.

Where centerline stations fall in an existing trail, obstruction, or roadway, stakes shall be offset left or right from centerline (perpendicular to tangents and on the radial lines of curves) clear of the trail, obstruction, or roadway, and the offset distance marked on the side facing the centerline. The centerline point shall be a 20-penny or larger nail, flagged, and driven at least 1 inch below the road surface.

The survey line shall be cleared to facilitate travel and surveying. Clearing slash shall be removed from the travel or work area. All brush and trees shall be cut as near to the ground as possible.

170.09 Referencing Centerline

The contractor shall reference centerline control points, which will be intervisible after clearing is completed to facilitate reestablishment of the centerline. References shall be measured to the precision of the centerline survey. References shall consist of two intersecting lines having an included angle of at least 30 degrees. The forward reference shall be placed a minimum of 25 feet outside the clearing limits as computed from the preliminary slope stake printout notes, and the rear hub or point on each line shall be not less than 30 feet beyond the forward hub or point. Reference points shall be marked with hubs and tacks.

170.10 Vertical Control & "L" Profile Levels

Bench marks established during the P-line survey that are within the clearing limits shall be relocated to points 20 feet or more outside the clearing limits. Elevation of relocated bench marks shall be determined by closed level circuits.

Bench marks shall be constructed to be permanent and to allow a level rod to stand vertically and squarely on the mark. Bench marks may be established by driving a 40-penny or larger nail into a notch cut in the base of a tree, by marking a point on a stable rock, or by other approved means. Spikes in trees shall be less than 12 inches above the ground. Location and descriptions of relocated bench marks shall be recorded in the level notes. At least two bench marks shall be set at each bridge and structural plate culvert site.

A closed level circuit shall be run over the L-line stations between bench marks to determine centerline ground elevations to the nearest 0.1 foot and to verify bench marks.

170.11
Discrepancies

The contractor shall compare the staked centerline horizontal and vertical alignment with the design data. Differences between previously recorded and observed elevations of bench marks shall be referred to the Engineer. Differences exceeding 1 degree in angle found between the horizontal alignment data SHOWN ON THE DRAWINGS and the alignment observed on the ground shall be referred to the Engineer. Differences in centerline profile elevations exceeding 1 foot at any two or more consecutive points shall be reported to the Engineer for evaluation and possible revision. Staking of these areas shall be deferred until these differences are resolved by the Engineer.

170.12
L Topography
Cross Sections

Cross sections shall be taken at right angles to tangents and normal to curves at every staked point on the "L" profile line. The contractor shall determine the elevations of significant breaks in topography, breaks in the designed roadway template, and cross-section reference points. Ground shots for these cross sections shall be recorded in terms of feet plus or minus from ground at centerline, and horizontal distances from centerline. Cross sections shall be measured and recorded to the neareast 0.1 foot in elevation and nearest foot in horizontal distance, and shall extend approximately 20 feet beyond the designed clearing and grubbing limit on cut sections and approximately 20 feet beyond the toe of fill on fill sections.

Cross sections shall be identified at each end of the cross section with lath marked to show centerline station and the horizontal and vertical distance to the centerline.

Cross-section data shall be returned to the Engineer for recomputation of earthwork quantities and slope stake "catchpoint" printouts.

Slope stakes established during the "L" topography cross section phase of the work may be subject to relocation to adjust earthwork quantities.

170.13
Slope Stakes,
Clearing Limits,
& Reference
Stakes

Slope catchpoints, clearing limits, and slope reference stakes shall be established on both sides of the centerline at each 'L' station established. The position of these stakes shall be determined by methods that will produce on the ground the designed template shown in the slope stake survey notes to the precisions shown in table 170-2 and specified for this contract. The slope stake "catchpoint distance" shown in the printout may be used as a trial location to initiate slope staking.

The cut or fill and horizontal distance to centerline, to bottom of ditch, or to shoulder as DESIGNATED by the Engineer shall be recorded on the slope stakes and in the slope stake notes as shown on figure 170-2.

Clearing limits shall be set on both sides of the centerline at each established "L" station within the tolerance shown on table 170-2. The clearing limit shall be located on the ground to the dimensions SHOWN ON THE DRAWINGS and marked with lath, flagging, or other methods approved by the Engineer. The total horizontal

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distance from the centerline to the clearing limit at each section shall be recorded to the nearest foot in the field book.

The contractor shall establish slope reference stakes at a minimum horizontal distance of 10 feet outside the clearing limits and record on the stakes the horizontal distance to centerline and the vertical distance to the construction grade. The offset from the slope stake catchpoint, and slope stake catchpoint information as shown in figure 170-2, shall also be recorded on the reference stake, and in the slope stake book.

The elevation and location of slope reference stakes shall be verified for accuracy by:

(a) For Precision A. A differential level run over the reference stakes between bench marks.

(b) For Precisions B & C. Differential leveling between slope reference stakes of adjacent sections.

170
.13

Where the difference in reference stake elevation between that established by slope staking and that observed by differential leveling exceeds the allowed tolerance, the slope stake shall be reset.

170.14 Monuments of Property Boundaries or Surveys of Other Agencies

If property boundary or survey monuments, or survey markers of other agencies, are found within or adjacent to the construction limits, the contractor shall immediately notify the Engineer.

170.15 Staking Culverts

Slope stakes and slope reference stakes shall be set at all culvert locations. A culvert reference stake and hub shall be set on the centerline of the culvert 10 feet from each end or beyond the clearing limit, whichever is greater. The following shall be recorded on these stakes:

(a) Diameter, actual field measured length, and type of culvert.

(b) The vertical and horizontal distance from hubs to the invert at the ends of the culvert.

When SHOWN ON THE DRAWINGS, headwalls for culverts shall be staked by setting a hub with a guard stake on each side of the culvert on line with the face of the headwall. (This work shall be performed after clearing is completed.)

170.16 Staking Drain Dips

Slope stakes and slope reference stakes shall be established on the projected centerline of the bottom of the dip at all drain dip locations as SHOWN ON THE DRAWINGS.

170.17 Staking Major Structures

(a) Bridges. Bridge locations shall be designated on the ground by establishing reference points for the bridge centerline and the transverse centerline of one pier or abutment. Reference points shall be hubs and tacks set online beyond the construction limits and marked to identify the point and distance to the point referenced. At least one bench mark shall be set on each side of the stream beyond construction limits but close enough to the bridge site to allow direct leveling between the bench marks and the bridge without an intermediate setup. All of the above information shall be recorded in a separate book that includes a sketch showing the stream, bridge, and location of all construction stakes set. Staking shall be done to the accuracy standards shown in table 170-1.

(b) Cattleguards. Cattleguards shall be staked as SHOWN ON THE DRAWINGS.

(c) Other Structures. When required, other structures shall be staked as described in SPECIAL PROJECT SPECIFICATIONS and/or as SHOWN ON THE DRAWINGS.

170.18 Grade Finishing Stakes

Finishing stakes shall be set when shown in the SCHEDULE OF ITEMS. Subgrade finishing stakes shall be blue tops. Base course finishing stakes shall be red tops.

Stakes shall be nominal 1-inch by 1-inch hubs and shall be of sufficient length to provide a solid set.

Finishing stakes shall be placed on the staked cross section and road template line. A stake shall be set at each shoulder and at centerline. Additional stakes shall be set when SHOWN ON THE DRAWINGS.

Finishing stakes shall be set when subgrade is within 0.5 feet, or base course is within 0.2 feet of final grade. The stakes shall be set to the nearest 0.02 feet of the measured grade line.

170.19 Marking Stakes

All stakes shall be legibly marked in the format shown in figure 170-1 with a stake pencil that leaves an imprint or with waterproof ink. Marking shall conform to the nomenclature below:

PI	Point of intersection of tangents
PC	Point of curvature
POC	Point on curve
PT	Point of tangency
POT	Point on tangent
RP	Reference point
P	P-line (preliminary location line)
L	L-line (final location line)
BM	Bench mark
TBM	Temporary bench mark
BT	Begin taper (any)
ET	End taper (any)
BFTO	Begin full turnout
EFTO	End full turnout
BFEW	Begin full extra widening
EFEW	End full extra widening
DD	Drain dip
C	Cut
F	Fill
℄	Centerline
D	Ditch
W	Width

170.20 Stake Approval & Maintenance

Construction work shall not begin within a roadway segment until the stakes, marks, and controls established by the contractor have been approved in writing by the Engineer. The minimum segment for approval shall be 2,000 feet or the length of the project, whichever is less.

Approval of the construction staking will not relieve the contractor of the responsibility for maintaining the survey work and for correcting errors, whether the errors are discovered during the actual survey work or in subsequent phases of the project. Stakes within the roadway need not be maintained after clearing operations have started.

MEASUREMENT

170.21 Method

The method of measurement, described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Reestablishing P-line includes all work needed to replace missing portions of the P-line that are necessary for the determination of L-line tangents. When listed in the SCHEDULE OF ITEMS, the quantity shall be the number of stations, measured to the nearest 0.1 station, of P-line reestablished. When the length of P-line to be replaced does not exceed 10 percent of the measured length of the L-line, reestablishing P-line will be considered incidental to establishing centerline, and no separate payment will be made.

Establishing centerline includes all work necessary to establish and reference the centerline, establish vertical controls, determine the centerline profile elevations, and cross-section the original ground from the centerline datum established by this survey. The quantity shall be the number of miles measured to the nearest 0.01 mile of centerline completed and accepted.

Slope staking includes all work necessary to establish slope stakes, clearing limits, and reference stakes from a previously established centerline. The quantity shall be the number of miles, measured to the nearest 0.01 mile, of previously established centerline completed and accepted.

170.21

Finish staking includes all work necessary to reestablish the centerline to control placement of finish stakes and set the finish stakes. The quantity shall be the number of miles, measured to the nearest 0.01 mile, of previously established centerline completed and accepted.

Staking major structures includes all work necessary to establish lines and grades for the construction of the structure(s). The quantity shall be the actual number of structures of the type shown in the SCHEDULE OF ITEMS completed and accepted.

PAYMENT

170.22 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
170(01)	Reestablish P-line, Precision _____	STA.
170(02)	Establish Centerline, Precision _____	MI.
170(03)	Slope Staking, Precision _____	MI.
170(04)	Finish Staking, Subgrade, Precision _____ . . .	MI.
170(05)	Finish Staking, Base Course, Precision _____ . .	MI.
170(06)	Staking Major Structure(s), Type ___, Precision _____	EA.

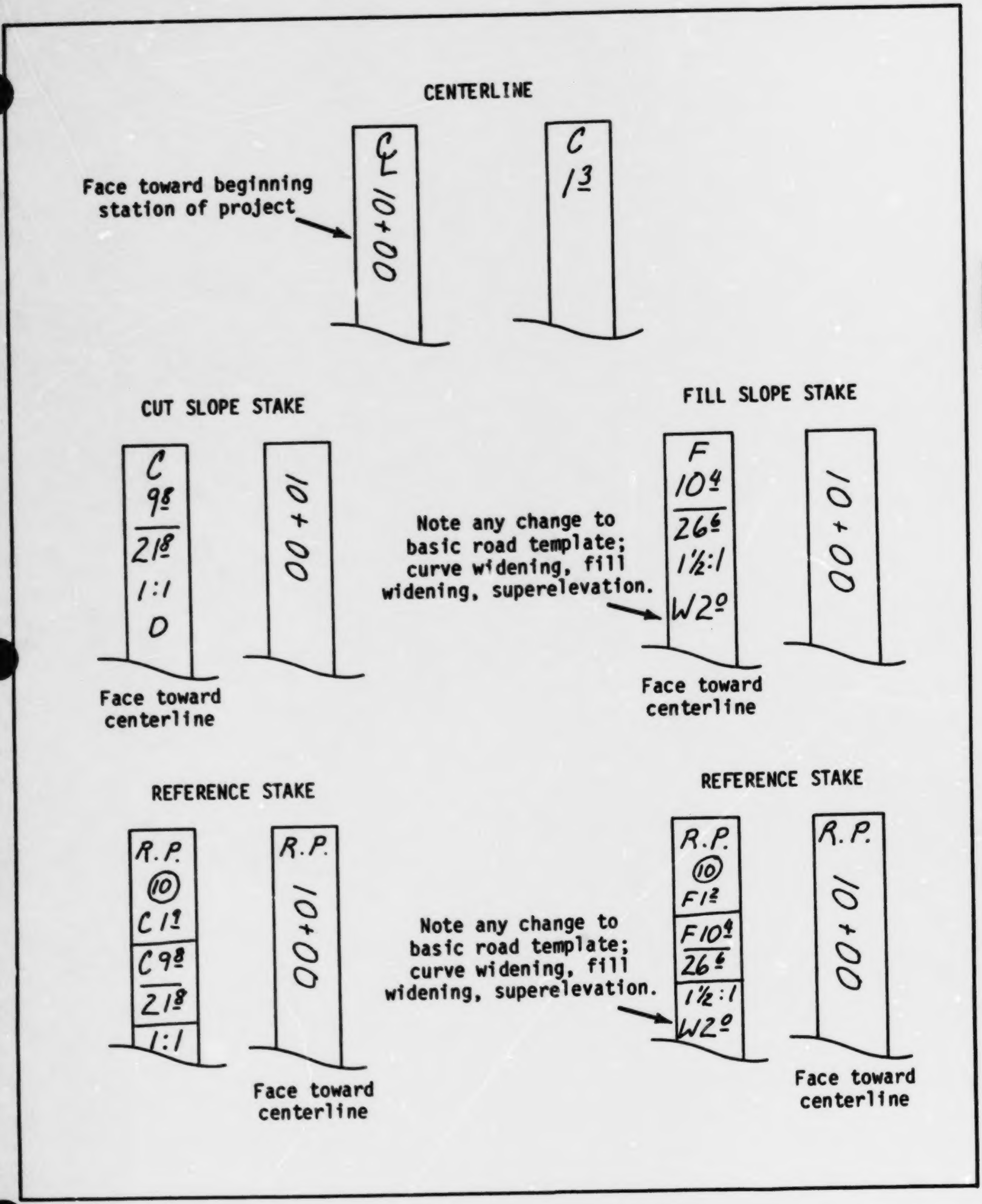
CENTERLINE
Face toward beginning station of project
℄
10+00
C
$1^{\underline{3}}$
CUT SLOPE STAKE
C
$9^{\underline{8}}$
$21^{\underline{8}}$
1:1
0
10+00
Face toward centerline
FILL SLOPE STAKE
F
$10^{\underline{4}}$
$26^{\underline{6}}$
1½:1
$W2^{\underline{0}}$
10+00
Note any change to basic road template; curve widening, fill widening, superelevation.
Face toward centerline
REFERENCE STAKE
R.P.
⑩
$C1^{\underline{9}}$
$C9^{\underline{8}}$
$21^{\underline{8}}$
1:1
R.P.
10+00
Face toward centerline
REFERENCE STAKE
R.P.
⑩
$F1^{\underline{2}}$
$F10^{\underline{4}}$
$26^{\underline{6}}$
1½:1
$W2^{\underline{0}}$
R.P.
10+00
Note any change to basic road template; curve widening, fill widening, superelevation.
Face toward centerline

Figure 170-1.--Construction stakes.

STA.	ELEV. ℄ GRADE	ELEV. ℄ GRND.	DIST. ℄ TO SHOULDER		WIDENING		DITCH PT.		SUPER ELEV.									
			LT.	RT.	LT.	RT.	LT.	RT.			* * *		* * *		* * *	* * *		
10 00	3213.3	3214.6	9	9	—	2	12	—	—	$+8^{8}$	$+6^{5}$	$+5^{2}$	$+4^{9}$	$+1^{3}$	0^{0}	-2^{8}	-9^{5}	-10^{4}
										21^{8}	12^{0}	9^{0}	4^{8}	○	4^{3}	11^{0}	19^{4}	26^{6}
										**			*			*		**
										10	$+10^{7}$		C			$F10^{4}$	-11^{6}	10
										$C10^{7}$	31^{8}		9^{8}			26^{6}	36^{6}	$F11^{6}$
										31^{8}			21^{8}			1½:1		36^{6}
										$C9^{8}$			1:1			W2		$F10^{4}$
										21^{8}			D					26^{6}
										1:1								1½:1
										D								W2
10+50			9	9	—	2	12	—	—									

* Data written on slope stake.

** Data written on reference stake.

D Indicates elevation difference to bottom of ditch.

( ) Template data.

*** Omit for Option II.

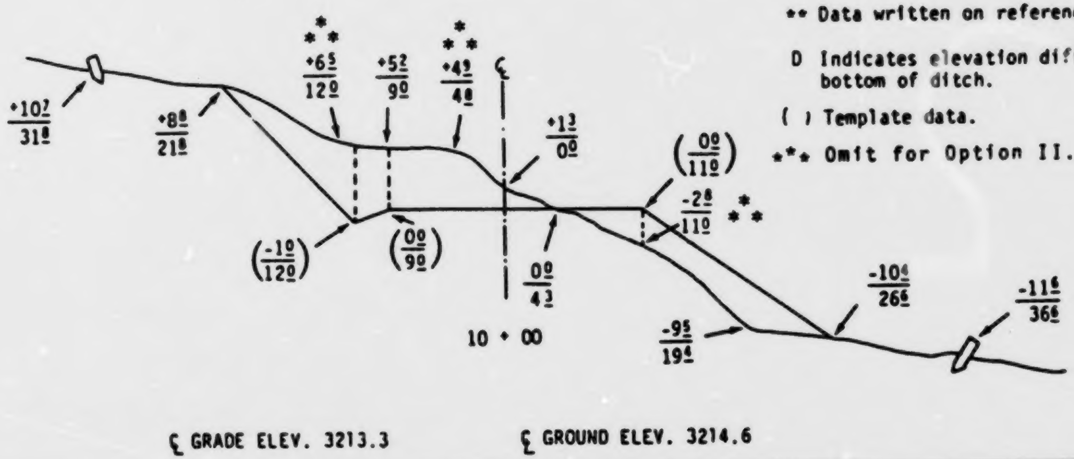
$\frac{+10^{7}}{31^{8}}$
$\frac{+8^{8}}{21^{8}}$
* * *
$\frac{+6^{5}}{12^{0}}$
$\frac{+5^{2}}{9^{0}}$
* * *
$\frac{+4^{9}}{4^{8}}$
℄
$\frac{+1^{3}}{0^{0}}$
$\left(\frac{0^{0}}{11^{0}}\right)$
$\frac{-2^{8}}{11^{0}}$
* * *
$\left(\frac{-1^{0}}{12^{0}}\right)$
$\left(\frac{0^{0}}{9^{0}}\right)$
$\frac{0^{0}}{4^{3}}$
10 + 00
$\frac{-9^{5}}{19^{4}}$
$\frac{-10^{4}}{26^{6}}$
$\frac{-11^{6}}{36^{6}}$
℄ GRADE ELEV. 3213.3
℄ GROUND ELEV. 3214.6

Figure 170-2.--Slope-stake note entries related to actual ground elevations.

Table 170-1.--Accuracy requirements for reestablishing P-line, traverse, and level circuits.

Precision Class	Minimum Position Closure	Angular Accuracy	L-Line Tangent Control Points[a]	Vertical Closure[b]
A (Bridges)	1/10,000	2 sets, direct/reverse 10" rejection limit	N/A	0.035 $\sqrt{M}$ or 0.002/sta.[c]
B	1/5000	2 sets, direct/reverse 20" rejection limit	0.1'	0.05 $\sqrt{M}$ or 0.02 ft/sta.[c]
C	1/1000	1 set, direct/reverse 1' rejection limit	0.2'	0.10 $\sqrt{M}$ or 0.05 ft/sta.[c]

[a] Accuracy of offset measurement.
[b] M is number of miles in traverse.
[c] Use least value.

Table 170-2.--Cross section and slope-stake precision.

Item	Precision		
	A	B	C
Allowable deviation of cross section line projection from a true perpendicular to tangents, a true bisector of angle points, or a true radius of curves.	± 2°	± 3°	± 3°
Cross section topography measurements shall be taken so that variations in ground from a straight line connecting the cross section points will not exceed:	0.5 ft	1.0 ft	2.0 ft
Horizontal and vertical accuracy for cross sections. In feet or percentage of horizontal distance measured from traverse line, whichever is greater.	0.1 ft or 0.4%	0.15 ft or 0.6%	0.2 ft or 1.0%
Horizontal and vertical accuracy for slope stake, slope stake references, and clearing limits. In feet or percentage of horizontal distance measured from centerline or reference stake, whichever is greater.			
a. Slope reference stakes and slope stakes.	0.1 ft or 0.4%	0.15 ft or 0.6%	0.2 ft or 1.0%
b. Clearing limits.	1.0 ft	1.0 ft	1.0 ft

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SECTION 200 EARTHWORK

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Section 201 - Clearing & Grubbing

DESCRIPTION

201.01
Work

This work shall consist of clearing, grubbing, trimming, removing, and disposing of or treatment of timber, construction slash, and debris. This work shall also include preservation of vegetation and objects DESIGNATED to remain from injury or defacement.

CONSTRUCTION

201.02
Clearing & Grubbing

All debris, trees, stumps, roots, and other protruding vegetative material within the clearing limits, not DESIGNATED to remain, shall be cleared, grubbed, removed, and disposed of, except the following:

(a) Undisturbed stumps outside the roadway or in embankment areas, provided they do not extend more than 12 inches above the original ground (measured from the uphill side) nor closer than 2 feet to the finished subgrade or 1 foot to any slope surface or as otherwise SHOWN ON THE DRAWINGS and they do not interfere with the placement or compaction of embankments.

(b) Grubbing of pits, channel changes, rock sections, and ditches, below the depth of the proposed excavation.

All roots over 3 inches in diameter within the roadbed area shall be grubbed to a minimum depth of 6 inches below subgrade. Roots over 3 inches in diameter protruding from the excavated slope shall be cut flush with the excavated slope surface.

Unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS, trees shall be felled into the area being cleared when ground conditions, tree lean, and shape of clearing permit. Controlled felling shall be used that will ensure the direction of fall when necessary to prevent damage to property, structures, trees DESIGNATED to remain, or traffic.

Fire-dangerous dead trees or unstable live trees, DESIGNATED by the Engineer within 200 feet slope distance of the centerline of roads shall be cut off not more than 12 inches above the uphill ground line and treated in accordance with Subsections 201.03 and 201.05.

Branches on remaining trees or shrubs shall be trimmed to give a clear height of 14 feet above the roadbed unless otherwise SHOWN ON THE DRAWINGS. Tree limbs shall be trimmed as near flush with the trunk as practicable.

201.03
Utilization of
Timber

Merchantable timber is timber that meets utilization standards in the SPECIAL PROJECT SPECIFICATIONS. Logging methods and utilization shall conform to the following:

(a) Felling and Bucking. Felling shall be done to minimize damage to merchantable timber and damage to remaining trees outside of clearing limits. Felling shall be done with saws or shears unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Bucking shall be done to permit removal of all minimum pieces set forth in SPECIAL PROJECT SPECIFICATIONS.

(b) Utilization and Removal of Timber. Trees that equal or exceed the diameters and minimum lengths listed in the SPECIAL PROJECT SPECIFICATIONS and contain one minimum piece shall be removed or disposed of by one of the following methods as shown in the SCHEDULE OF ITEMS.

(1) The disposal of merchantable timber designated for removal shall be done in accordance with the B(BT) provisions of the Timber Sale Contract.

(2) Logs meeting utilization standards shall be limbed and decked at locations SHOWN ON THE DRAWINGS or at locations approved by the Engineer. Decking shall be done in such a manner that logs are piled parallel one to the other, can reasonably be removed by standard log loading equipment, will not damage standing trees, and will not roll. Decks shall be free of brush and soil.

(3) Removal from Government Land. Merchantable timber, designated for removal, shall become the property of the contractor without charge and removed from Government land. This timber shall not be exported from the United States nor used as substitution (as defined in 23 CFR 223.10) for timber from private lands exported by the contractor or an affiliate directly or indirectly.

(4) Disposal as Unmerchantable Timber. Timber on this project is not considered merchantable and shall be disposed of in accordance with Subsection 201.05 for the treatment methods SHOWN ON THE DRAWINGS and in the SCHEDULE OF ITEMS.

201.04 Pioneer Roads

The construction of pioneer roads shall be confined to inside the roadway unless otherwise approved by the Engineer.

201 .03

201.05 Slash Treatment

Treatment of construction slash larger than 3 inches in diameter and 3 feet in length shall be accomplished by one or more of the following methods as shown in the SCHEDULE OF ITEMS:

(1) Windrowing Construction Slash

(2) Windrowing of Large Material

(3) Windrowing and Covering

(4) Scattering

(5) Burying

(6) Chipping

(7) Piling and Burning

(8) Decking Unmerchantable Material

(9) Disposal in Cutting Units

(10) Removal

(11) Piling

(12) Placing Slash on Embankment Slopes

Pieces of wood less than 3 inches in diameter and 3 feet in length may be scattered within the clearing limits.

(a) All Methods. No construction slash shall be deposited in lakes, meadows, streams, or streambeds. Construction slash that interferes with drainage structures shall be removed immediately.

Trees adjacent to the clearing limits scorched or damaged beyond recovery shall be felled and disposed of in accordance with Subsection 201.03 or treated as construction slash.

(b) Specific Methods

(1) Windrowing Construction Slash. Unless specified otherwise in the SPECIAL PROJECT SPECIFICATIONS, the contractor

shall meet the following requirements. Areas used to windrow construction slash shall be cleared to accommodate the windrow. Construction slash shall be placed outside the roadway in neat, compacted windrows laid approximately parallel with and along the toe-line of embankment slopes. The top of windrows shall not extend above the subgrade. All material in the windrow shall be matted down with construction equipment to form a compact and uniform pile. Windrows shall have 16-foot minimum length breaks at least every 200 feet. Windrows shall not be placed against trees. A pioneer road may be constructed to provide an area for placement of windrows provided the excavated material is kept within the clearing limits and does not adversely affect the road construction.

(2) Windrowing of Large Material. Construction slash 10 inches or more in diameter at the small end and 6 feet or more in length shall be windrowed as in (1) above. Smaller material shall be treated by one or more of the other included methods for slash treatment.

(3) Windrowing and Covering. Contruction slash shall be placed and compacted as in (1) above and shall be covered with at least 6 inches of rock and soil to form a smooth and uniform windrow.

(4) Scattering. Unless specified otherwise in the SPECIAL PROJECT SPECIFICATIONS, the contractor shall meet the following requirements. Construction slash shall be scattered outside the clearing limits without damaging trees. All logs shall be limbed. Logs and stumps shall be placed away from trees, positioned so they will not roll, and not be placed on top of one another. Other construction slash shall be limbed and scattered to reduce slash concentrations.

(5) Burying. Construction slash shall be buried at the locations SHOWN ON THE DRAWINGS and DESIGNATED on the ground. Construction slash shall be matted down in layers and covered with at least 2 feet of rock and soil. The final surface shall be smoothed and sloped to drain.

(6) Chipping. Construction slash up to at least 4 inches in diameter and longer than 3 feet shall be processed through a chipping machine. Chips shall be deposited on embankment slopes or outside the roadway to a loose depth not exceeding 6 inches. Minor amounts of chips may be permitted within the roadway if they are thoroughly mixed with soil and do not form a layer.

(7) Piling and Burning. Construction slash shall be deposited in areas SHOWN ON THE DRAWINGS and DESIGNATED on the ground. Piles shall be constructed so that burning does not damage standing trees. If burning is incomplete, the slash remaining shall be repiled and burned until pieces are reduced to less than 3 inches in diameter and 3 feet in length. These pieces shall then be scattered.

(8) Decking Unmerchantable Material. Logs not meeting utilization standards in Subsection 201.03 and other material that exceeds the diameter and length shown in the SPECIAL PROJECT SPECIFICATIONS shall be decked in areas SHOWN ON THE DRAWINGS. Other locations may be approved by the Engineer.

Material shall be cut into lengths not to exceed 32 feet and all limbs removed. Decks shall be stable and free of brush and soil. Other material shall be treated according to slash treatment methods SHOWN ON THE DRAWINGS and in the SCHEDULE OF ITEMS.

(9) Disposal in Cutting Units. Construction slash from within cutting units and 200 feet adjacent thereto shall be disposed of with logging slash. Such construction slash shall be deposited at least 50 feet inside the cutting unit boundary in

such a manner that it will not inhibit logging of the unit and that it may be treated by the prescribed logging slash treatment method.

(10) Removal. Construction slash shall be removed or hauled to locations SHOWN ON THE DRAWINGS and DESIGNATED on the ground.

(11) Piling. Construction slash shall be piled in areas SHOWN ON THE DRAWINGS and DESIGNATED on the ground for later burning or disposal by others. Piles shall be placed and constructed so burning will not damage remaining trees. All stumps shall be reasonably free of dirt. Unmerchantable logs shall be cut into lengths less than 20 feet prior to placement in the pile.

(12) Placing Slash on Embankment Slopes. Construction slash shall be placed on completed embankment slopes to reduce soil erosion where SHOWN ON THE DRAWINGS. Construction slash shall be placed as flat as practicable on the completed slope. Slash shall be placed from the toe of the embankment to a point at least 2 feet below subgrade elevation. Priority for the use of available slash shall be given to (1) through fills, (2) inside of curves, and (3) ditch relief outlets.

MEASUREMENT

201.06 Method

The method of measurement, described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Linear measurements will be horizontal along the road centerline.

Quantities will be number of acres and fractions thereof within the clearing limits, regardless of the amount of work required.

The quantity for individual removal of trees will be the number of trees of the various size-designations removed. Tree diameters will be measured at a height of 12 inches above the ground. Trees less than 6 inches in diameter will not be counted.

Size of Least Diameter At Height of 12 Inches	Pay Item Designation
** Over 6 inches to 24 inches	Small
Over 24 inches to 40 inches	Medium
Over 40 inches	Large

When an item for "Individual Removal of Trees, Miscellaneous" is shown in the SCHEDULE OF ITEMS, measurement will be the number of trees designated to be removed regardless of size.

PAYMENT

201.07 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
201(01)	Clearing and Grubbing, Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, Logs ______ ______, and Stumps ______ ______ ______, Utilization of Timber ______	ACRE
201(02)	Clearing and Grubbing, Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, Logs ______ ______ ______, and Stumps ______ ______ ______, Utilization of Timber ______	STA.

201(03)	Clearing and Grubbing, Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, Logs ______ ______ ______, and Stumps ______ ______ ______, Utilization of Timber ______	MI.
201(04)	Clearing and Grubbing, Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, Logs ______ ______ ______, and Stumps ______ ______ ______, Utilization of Timber ______	L.S.
201(05)	Individual Removal of Trees, Small; Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, and Logs ______ ______ ______ ______, Utilization of Timber ______	EA.
201(06)	Individual Removal of Trees, Medium; Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, and Logs ______ ______ ______ ______, Utilization of Timber ______	EA.
201(07)	Individual Removal of Trees, Large; Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, and Logs ______ ______ ______ ______, Utilization of Timber ______	EA.
201(08)	Individual Removal of Trees, Miscellaneous; Slash Treatment Methods for Tops and Limbs ______ ______ ______ ______, and Logs ______ ______ ______ ______, Utilization of Timber ______	EA.
201(09)	Individual Removal of Stumps, Slash Treatment Methods ______	EA.

Section 202 - Removal of Structures & Obstructions

DESCRIPTION

202.01 Work

This work shall consist of the removal and disposal, wholly or in part, of all buildings, structures, fences, old pavement, and all other obstructions within the clearing limits that are not DESIGNATED or permitted to remain, except for obstructions to be removed and disposed of under other contract items. It shall also include the salvaging of DESIGNATED materials and backfilling the resulting trenches, holes, and pits.

CONSTRUCTION

202.02 Performance

The contractor shall perform the work described in Subsection 202.01 as SHOWN ON THE DRAWINGS. All DESIGNATED salvageable material shall be removed without unnecessary damage, in sections or pieces that may be readily transported, and shall be stored at locations SHOWN ON THE DRAWINGS. All other material not DESIGNATED for salvage shall be removed from the project or disposed of, as described in the SPECIAL PROJECT SPECIFICATIONS. The source, type, and method of placement of material to fill the cavities left by the removed structure shall be as SHOWN ON THE DRAWINGS.

202
.01

202.03 Removal of Bridges, Culverts, & Other Structures

The removal of existing culverts within embankment areas will be required only as necessary for the installation of new structures. No portion of any existing abandoned culvert shall be left within a distance equal to its diameter or 2 feet, whichever is greater, from the subgrade or the embankment slope. Culvert ends shall be crushed. All removed culvert sections that are not DESIGNATED for salvage or to be relaid shall be disposed of as described in the SPECIAL PROJECT SPECIFICATIONS.

The substructures of existing structures shall be removed down to the natural stream bottom, and those parts outside of a stream shall be removed down to at least 1 foot below natural ground surface or finished ground line, whichever is lower. Where portions of existing structures lie wholly or in part within the limits for a new structure, they shall be removed to accommodate the construction of the proposed structure.

Bridges to be salvaged shall be dismantled without unnecessary damage. Steel members shall be matchmarked unless matchmarking is waived by the Engineer and a drawing prepared showing matchmarking with the structural location of each member. All salvaged material shall be stored at locations SHOWN ON THE DRAWINGS.

Structures not DESIGNATED for salvage shall be disposed of as described in the SPECIAL PROJECT SPECIFICATIONS.

202.04 Removal of Pipe, Other than Culverts

Pipe shall be carefully removed and precautions taken to avoid damaging the pipe. Pipes to be relaid shall be stored when necessary to prevent loss or damage before relaying. The contractor shall replace without additional compensation all sections lost from storage or damaged by the use of improper methods.

MEASUREMENT

202.05 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

PAYMENT

202.06 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
202(01)	Removal of Structures and Obstructions	L.S.
202(02)	Removal of _____	EA.
202(03)	Removal of _____	L.F.
202(04)	Removal of _____	S.Y.
202(05)	Removal of _____	L.S.

Section 203 - Excavation & Embankment

DESCRIPTION

203.01
Work

This work shall consist of excavation and shaping of roadway, borrow excavation, drainage excavation, removal of slide material, excavation of unsuitable material, embankment construction, and disposal of all excavated material necessary for the completion of construction including roadway ditches, channel changes, furrows, slope rounding, benches, berms, dips, approaches, and subsidiary work.

203.02
Excavation

Excavation shall consist of the excavation and disposal of all excavated material, regardless of its nature, that is not included under other pay items listed in the SCHEDULE OF ITEMS.

203.03
Borrow Excavation

Borrow excavation shall consist of the excavation and utilization of material from sources SHOWN ON THE DRAWINGS or described in the SPECIAL PROJECT SPECIFICATIONS. Additional sources of borrow excavation will be subject to approval in advance by the Engineer. Development of sources shall be in accordance with Section 611.

CONSTRUCTION

203
.01

203.04
Clearing & Grubbing

Clearing and grubbing shall be accomplished in accordance with Section 201 before work under Section 203 begins, except pioneer roads and slash disposal, and grubbing of stumps when approved by the Engineer may proceed concurrently with excavation, and the burning of slash may be delayed until weather permits. Excavation and placement operations shall be conducted so material to be treated under Section 201 will not be incorporated in the roadway.

203.05
Pioneering

Pioneering operations for the top of excavation slopes, toe of embankments, or pioneer road construction shall prevent undercutting of the final excavation slope, depositing of materials outside of the roadway limits, and any restriction of drainage.

203.06
Utilization of Excavated Materials

All suitable, excavated material shall be used in the construction of embankments, subgrades, shoulders, slopes, bedding, and backfill for structures and for other purposes as SHOWN ON THE DRAWINGS.

(a) Excess Excavation. Designed excess excavation shall be disposed of as SHOWN ON THE DRAWINGS.

(b) Rock for Slope Protection. Excavated rock suitable for protection of embankments may be conserved and used in lieu of a DESIGNATED materials source.

(c) Conserving Material. Material encountered in the excavation, suitable for cushion, road finishing, or other purposes, may be conserved and utilized instead of materials from DESIGNATED sources. Excessively wet material that is otherwise suitable for embankment shall be field drained and dried before placement.

(d) Excavation of Unsuitable Material. Unsuitable material shall be excavated. Disposal will be as SHOWN ON THE DRAWINGS. Excavated areas shall be backfilled with suitable material when necessary to complete the work. Frozen material shall not be placed in embankments. Rocks that are too large to be incorporated into the embankment shall be broken for incorporation into the embankment, maneuvered to the face of the embankment and embedded so that they will not roll or obstruct the use and maintenance of the roadbed, or moved to locations approved by the Engineer.

(e) Conservation of Topsoil. When SHOWN ON THE DRAWINGS, suitable topsoil shall be removed, transported, and deposited in the DESIGNATED stockpile areas.

(f) Abandoned Structures and Obstructions. Abandoned structures and obstructions shall be treated in accordance with Section 202.

203.07
Drainage Excavation

Drainage excavation shall include construction of side ditches, minor channel changes, inlet and outlet ditches, furrow ditches, ditches constructed along the road but beyond the roadway limits, and other minor earth drainage structures as SHOWN ON THE DRAWINGS. Excavated material shall be utilized in accordance with Subsection 203.06.

203.08
Finishing Roadbed

For roads receiving aggregate base or surface course, only rocks that do not protrude above the subgrade more than one-third of the depth of the base or surface course, or 3 inches, whichever is less, may remain in place.

For unsurfaced roads, unless otherwise SHOWN ON THE DRAWINGS, the top 4 inches below the finished road surface shall not contain rocks larger than 4 inches in greatest dimension. Oversize material shall be removed, reduced to acceptable size, or covered by importing suitable material approved by the Engineer.

The subgrade shall be visibly moist during shaping and dressing. Low sections, holes, cracks, or depressions shall be brought to grade with suitable material approved by the Engineer. Final compaction of the subgrade shall meet the requirements of the embankment placing method specified.

203.09
Snow Removal

Snow or ice shall not be incorporated in the embankment. Snow shall be removed in advance of the work and deposited beyond the roadway limits in a manner that will not cause resource damage nor waste material.

203.10
Finishing Slopes

Finished slopes shall conform reasonably to the lines STAKED ON THE GROUND or SHOWN ON THE DRAWINGS. The finished slope shall be left in a roughened condition to facilitate the establishment of vegetative growth. The finish associated with template and stringline or handraking methods will not be allowed. Loose rock, loose debris, and other loose material, each of which is larger than 6 inches in diameter, shall be removed from the slope unless otherwise SHOWN ON THE DRAWINGS.

The tops of excavations, excluding areas of solid rock, shall be blended with the adjacent terrain by rounding where SHOWN ON THE DRAWINGS. Decomposed rock that may be cut without blasting or ripping shall be rounded. Earth overlying rock shall be rounded above the rock.

All rock excavations that require blasting shall be formed with controlled blasting techniques unless otherwise SHOWN ON THE DRAWINGS. Controlled blasting is defined as the controlled usage of explosives and blasting accessories in appropriately aligned and spaced drill holes for the purpose of producing a free surface or shear plane in the rock excavation slopes and of minimizing landscape damage, adjacent ground vibration, and overbreak. Presplitting is not intended unless SHOWN ON THE DRAWINGS and described in the SPECIAL PROJECT SPECIFICATIONS.

Unless directed otherwise by the Engineer, the contractor shall drill, blast, and excavate short test sections (not to yield in excess of 1,000 cubic yards) to determine the controlled blasting method, hole spacing, and charge best suited to the material encountered.

203.11
Overbuilding & Landscape & Stream Protection

Unless otherwise agreed to by the Engineer, excavation or embankment material shall be confined within the roadway limits to avoid overbuilding and to protect the landscape and streams.

203.12
Subgrade Treatments

Subgrade treatment shall consist of soil modification by admixing aggregates, placing geotextiles, fiber mat, wood corduroy, rock blanket, or other similar materials over areas of unsuitable embankment foundation material that are SHOWN ON THE DRAWINGS. The construction and material requirements for the type of subgrade treatment will be specified in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS.

203.13
Earth Berms

Permanent earth berms shall be constructed along the shoulder of the traveled way at locations SHOWN ON THE DRAWINGS. Material used in the construction of berms shall be well graded with no rocks having a dimension greater than one-fourth the height of the berm.

Acceptable material for the berm may be windrowed as the roadbed is constructed. When the local material is not acceptable, material shall be imported from approved sources. Material used for berm construction shall contain no frozen material, roots, sod, or other deleterious material. Material shall not be wasted over the embankment slope.

Compaction shall be accomplished by operating the spreading equipment over the full section of the berm.

203.14
Water

Water development, hauling, and application shall be in accordance with Section 207.

203.15
Embankment Placing Methods

(a) All Methods. When an embankment is to be placed across swampy ground and removal of unsuitable material or subgrade treatment is not required, the lower part of the embankment shall be constructed in a single layer to the minimum depth necessary to support construction equipment.

(b) Specific Methods. All embankments shall be placed by one or more of the following methods as SHOWN ON THE DRAWINGS and listed in the SCHEDULE OF ITEMS:

Method 1. Side Casting and End Dumping. Embankment may be placed by side casting and end dumping. Where material containing a large amount of rock is used to construct embankments, a solid embankment shall be provided by working smaller rocks and fines in with the larger rocks and fines to fill the voids.

Method 2. Layer Placement. Surfaces steeper than a ratio of 3 horizontal to 1 vertical (3:1) upon which embankment is to be placed, shall be roughened or stepped when SHOWN ON THE DRAWINGS to provide permanent bonding of new and old materials.

Embankment shall be layer placed, except over rock surfaces, in which case material may be placed by end dumping to the minimum depth needed for operation of spreading equipment. Each embankment layer shall be leveled and smoothed before placement of subsequent layers. Hauling and spreading equipment shall be operated uniformly over the full width of each layer.

Suitable material shall be placed in layers no more than 12 inches thick, except when the material contains rock more than 9 inches in diameter, in which case layers may be of sufficient thickness to accommodate the material involved. No layer shall exceed 24 inches before compaction.

Placing individual rocks or boulders greater than 24 inches will be permitted provided the embankment will accommodate them. Such rocks and boulders shall be at least 6 inches below subgrade. They shall be carefully distributed and the voids filled with finer material to form a dense and compacted mass.

Where material containing large amounts of rock is used to construct embankments, the layers may be of sufficient thickness to accommodate the material involved. A solid embankment with adequate compaction shall be constructed by working smaller rock and fines in with the larger rocks to fill the voids and by operating hauling and spreading equipment uniformly over the full width of each layer as the embankment is constructed.

Material shall be at a moisture content suitable to obtain a mass that will not visibly deflect under the load of the hauling and spreading equipment. Excessively wet material shall be handled in accordance with Subsection 203.06(c).

Method 3. Layer Placement (Roller Compaction). Embankments shall be placed as specified in Method 2. Placement shall be in horizontal layers not exceeding 12 inches prior to compaction except when the material contains rock more than 9 inches in diameter, in which case layers may be of sufficient thickness to accommodate the material involved. Compaction shall be obtained by equipment in compliance with the requirements of Subsection 212.02(a), (b), (c), or (d). Compaction equipment shall be operated over the full width of each layer until visible deformation of the layer ceases or in the case of the sheepfoot roller, the roller "walks out" of the layer. At least three complete passes shall be made.

Method 4. Controlled Compaction. Embankments shall be placed as specified in Method 2, except earth embankments shall be placed in horizontal layers not exceeding 12 inches (loose measure) and compacted. Material shall be at a moisture content suitable for attaining the required compaction. Embankments and the top 1 foot of excavation sections shall be compacted to at least 95 percent of the maximum density as determined by AASHTO T 99, Method C or D.

The density of the embankment material will be determined during the progress of the work in accordance with AASHTO T 191, T 205 or T 238; T 217, T 239, or T 255; and T 224.

Density requirements will not apply to portions of rock embankments that cannot be tested in accordance with approved methods. When this condition exists, compaction shall be provided by working smaller rocks and fines in with the larger rocks to fill the voids and by operating equipment over the embankment materials.

Method 5. Controlled Compaction Using Density Control Strips. The embankment placement requirements for Method 4 shall apply for this method except that compaction shall be performed in accordance with Section 212. Where portions of rock embankment are constructed that cannot be tested in accordance with approved methods, each layer shall be rolled full width with the same number of passes as the adjacent embankment containing material represented by a control strip.

Method 6. Special Project Controlled Compaction. Embankments shall be placed and compacted to at least 90 percent of the maximum density determined by AASHTO T 180, Method C or D, except that compaction of not less than 95 percent of AASHTO T 180, Method C or D, shall be obtained for a minimum depth of 1 foot below subgrade for the width of the roadbed in both excavation and embankment sections.

The density will be determined during the work in accordance with AASHTO T 191, T 205 or T 238; T 217, T 239 or T 255; and T 224.

203.16 Construction Tolerances

The tolerance class shall be as SHOWN ON THE DRAWINGS. Roadway ditches shall be constructed to flow in the direction SHOWN ON THE DRAWINGS.

Deviations shall be uniform in the direction of change for a distance of 200 feet or more along the project centerline.

Item	Tolerance Class[a] A	 B	 C	 D	 E	 F	 G	 H	 I	 J
Roadbed Width (Feet)	+0.5	+0.5	+1	+1	+1	+1	+1	+1.5	+1	+2
Subgrade Elevation (Feet)	±0.1	±0.2	±0.2	±0.5	±0.5	±1	±1	±1.5	±2	±3
Centerline Alignment (Feet)	0.2	0.2	0.5	0.5	1	1	1	1.5	2	3
Slopes, Excavation and Embankment (Percent Slope)[b]	±3	±5	±5	±5	±5	±5	±10	±10	±10	±10

[a] Maximum allowable deviation from construction stakes and drawings.
[b] Maximum allowable deviation from staked slope measured from slope stakes or hinge points.

203.17
(Reserved)

MEASUREMENT

203.18
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Quantities of excavation will include:

(a) Roadway excavation.

(b) Rock and unsuitable material below the required grade and unsuitable material beneath embankment areas.

(c) Furrow ditches outside the roadway, except when furrow ditches are included in the SCHEDULE OF ITEMS.

(d) Topsoil and other material removed and stockpiled as directed.

(e) Borrow material used in the work, except when borrow is included in the SCHEDULE OF ITEMS.

(f) The volume of conserved materials taken from stockpiles and used in the work, except topsoil included under other pay items.

(g) Slide material not attributable to negligence of the contractor.

Quantities of excavation will not include the following:

(a) Material used for other than approved purposes.

(b) Unauthorized excavation or borrow.

(c) Quantity of material excavated from slope rounding.

(d) Overbreakage from the backslope in rock excavation requiring blasting.

(e) Material scarified in place to receive the first layer of embankment.

(f) Benching or stepping existing ground for embankment foundation.

(g) Stepping or scaling cut slopes.

(h) Oversize material removed when finishing unsurfaced roads.

When designed quantities are DESIGNATED in the SCHEDULE OF ITEMS as the method of measurement, the quantities are estimated from design data based on undisturbed ground surface elevations.

When staked quantities are shown in the SCHEDULE OF ITEMS, excavation quantities will be determined by the average end area method using slope stake information taken prior to construction.

When actual quantities are DESIGNATED in the SCHEDULE OF ITEMS as the method of measurement, preliminary cross sections or comparable measurements will be taken of the undisturbed ground surface and quantities finally measured in accordance with the following:

(a) When excavation is DESIGNATED as a pay item in the SCHEDULE OF ITEMS, final cross sections or comparable measurements will be taken of the completed and accepted work.

(b) When embankment is DESIGNATED as a pay item in the SCHEDULE OF ITEMS, measurement will be in the final position.

(c) When borrow is DESIGNATED as a pay item by the cubic yard in the SCHEDULE OF ITEMS, measurement will be in the original position.

PAYMENT

**203.19
Basis**

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
203(01)	Excavation, Placement Method 1	C.Y.
203(02)	Excavation, Placement Method 2	C.Y.
203(03)	Excavation, Placement Method 3	C.Y.
203(04)	Excavation, Placement Method 4	C.Y.
203(05)	Excavation, Placement Method 5	C.Y.
203(06)	Excavation, Placement Method 6	C.Y.
203(07)	Excavation, Placement Method ____________ . . .	STA.
203(08)	Excavation, Placement Method ____________ . . .	MI.
203(09)	Excavation, Placement Method ____________ . . .	L.S.
203(10)	Borrow Excavation, Placement Method ______________________	C.Y.
203(11)	Borrow Excavation, Placement Method ______________________	TON
203(12)	Unsuitable Excavation	C.Y.
203(13)	Embankment, Placement Method ______________________________	C.Y.
203(14)	Embankment, Placement Method ______________________________	STA.
203(15)	Embankment, Placement Method ______________________________	MI.

203(16)	Subgrade Treatment, Type ______________________	S.Y.
203(17)	Rounding Cut Slopes	L.F.
203(18)	Drainage Excavation, Type ______________________	C.Y.
203(19)	Drainage Excavation, Type ______________________	L.F.
203(20)	Drainage Excavation, Type ______________________	EA.
203(21)	Furrow Ditches	L.F.
203(22)	Topsoil (Stockpiled)	C.Y.
203(23)	Earth Berms	L.F.

Section 204 - Soil Erosion & Water Pollution Control

DESCRIPTION

204.01
Work

This work consists of temporary measures as SHOWN ON THE DRAWINGS or specified in the SPECIAL PROJECT SPECIFICATIONS to control soil erosion and water pollution, through the use of berms, dikes, dams, sediment basins, silt fences, brush barriers, fiber mats, netting, gravel, mulches, grasses, slope drains, and other devices or methods.

The control provisions shall be coordinated with the permanent erosion control features in the contract to ensure economical, effective, and continuous protection throughout the construction period.

MATERIALS

204.02
Requirements

Materials shall meet the requirements of the following sections or subsections:

Emulsified Asphalt	702.03
Agricultural Limestone	713.02
Fertilizer	713.03
Seed	713.04
Mulch	713.05
Net Material	713.07
Geotextiles	720

All other materials shall be as SHOWN ON THE DRAWINGS or specified in SPECIAL PROJECT SPECIFICATIONS.

CONSTRUCTION

204.03
Performance

Prior to the start of construction, the contractor shall submit to the Engineer for approval a schedule for temporary and permanent control work for each phase of work (clearing and grubbing, grading, structures, borrow pits, and so forth). No work shall begin until the necessary controls for that particular phase of work have been installed as required.

All permanent erosion control features shall be incorporated into the project at the earliest practicable time as outlined in the approved schedule to minimize the need for temporary erosion control.

When required by the SPECIAL PROJECT SPECIFICATIONS, clearing and grubbing shall be scheduled and performed so that grading operations and permanent erosion control measures can follow without interference.

Temporary erosion and pollution control measures required due to the contractor's negligence, carelessness, or failure to install permanent controls as scheduled shall be performed by the contractor at his own expense.

Erosion control features shall be maintained by the contractor during the contract. Temporary controls shall be dismantled and disposed of as specified in SPECIAL PROJECT SPECIFICATIONS or as SHOWN ON THE DRAWINGS.

MEASUREMENT

204.04
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

PAYMENT

204.05 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment shall be made under:

Pay Item		Pay Unit
204(01)	Temporary Seeding and Fertilizing	ACRE
204(02)	Mulching	TON
204(03)	Asphaltic Material	GAL.
204(04)	Temporary Netting	S.Y.
204(05)	Straw/Hay Bales	EA.
204(06)	Gravel Blanket	C.Y.
204(07)	Silt Fence	L.F.
204(08)	Brush Barrier	L.F.
204(09)	Sediment Basin	EA.
204(10)	Berm	L.F.
204(11)	Dike	L.F.
204(12)	Dam	EA.
204(13)	Temporary Water Bars	EA.
204(14)	_______ for Soil Erosion and Pollution Control	EA.
204(15)	_______ for Soil Erosion and Pollution Control	L.F.
204(16)	_______ for Soil Erosion and Pollution Control	S.Y.
204(17)	_______ for Soil Erosion and Pollution Control	ACRE
204(18)	_______ for Soil Erosion and Pollution Control	M.S.F.
204(19)	_______ for Soil Erosion and Pollution Control	C.Y.
204(20)	Soil Erosion & Pollution Control	L.S.

204
.05

Section 206 - Structure Excavation

DESCRIPTION

206.01
Work

This work shall consist of the necessary excavation and backfill or disposal of all materials required for the construction of bridges and other major structures.

This work shall include the necessary diversion of live streams, bailing, pumping, draining, sheeting, bracing, construction of cribs and cofferdams, and the subsequent removal of cribs and cofferdams.

This work shall also include the furnishing and placing of approved foundation material to replace unsuitable material encountered below the foundation elevation of structures.

CONSTRUCTION

206.02
Clearing & Grubbing

All necessary clearing and grubbing in any area shall be completed in accordance with Section 201 before starting excavation in that area, except slash disposal as approved by the Engineer.

206.03
All Structures

The contractor shall notify the Engineer sufficiently in advance of the beginning of any clearing, grubbing, or excavation so cross sectional measurements may be taken of the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed until authorized by the Engineer.

Excavations for structures or structure footings shall be to the lines and grades or elevations SHOWN ON THE DRAWINGS. They shall be of sufficient size to permit the construction of structures or structure footings. The elevations of the bottoms of footings, as SHOWN ON THE DRAWINGS, shall be considered as approximate.

Boulders, logs, and any other unsuitable material encountered in the excavation shall be removed and disposed of at locations SHOWN ON THE DRAWINGS.

The contractor shall notify the Engineer when each excavation is completed. No footing shall be placed until the Engineer has approved the depth of excavation and the foundation material in writing.

Excavation shall conform to OSHA Standard 1926.652 or OSHA-approved State Plan Requirements.

All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface that is level, stepped, or serrated as approved by the Engineer. All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be completed until just before the footing is to be placed. When the foundation material is soft or otherwise unsuitable, the unsuitable material shall be removed and the area shall be backfilled with approved granular material. This foundation backfill material shall be placed and compacted in 6-inch layers up to the foundation elevation. Each layer shall be compacted in accordance with subsection 203.15(b), Method 4.

When foundation piles are used, the excavation shall be completed before the piles are driven. Foundation backfill shall be placed after the piles are driven. After the driving is completed, all loose and displaced material shall be removed, leaving a smooth, solid bed to receive the footing.

206.04
Utilization of Excavated Materials

All suitable excavated material shall be utilized as backfill or embankment. All surplus material shall be disposed of as SHOWN ON THE DRAWINGS. Excavated material shall be deposited in a manner that will not endanger the partly finished structure.

Unauthorized placement of excavated material in live streams will not be permitted. Any excavated material temporarily stored near a stream shall be removed before rising waters reach the stockpiled materials.

206.05 Cofferdams

Suitable and practically watertight cofferdams or cribs shall be used whenever a pay item for cofferdams is included. For this purpose, a cofferdam or crib is defined as an enclosed single- or double-wall braced structure with walls sheeted with timber, concrete or steel, and which shall extend well below the bottom of the excavation when practical. Earthen or rockfill dikes, dams, or embankments are not considered cribs or cofferdams for this purpose.

The design and construction of supporting systems, if used, shall be the responsibility of the contractor in accordance with the following provisions. The contractor shall submit four sets of drawings showing the proposed method of cofferdam or crib construction and four copies of the design calculations, fully annotated and referenced. The design calculations and drawings submitted shall bear the signature and seal of a registered professional engineer.

Supporting systems shall be designed to withstand the expected loads and pressures, including surcharge, water, and earth, which may occur during the period for which they are used. Surcharge, earth, and water pressure diagrams, and the method of supporting system analysis and design, shall meet accepted engineering practice. For new materials, the allowable working stresses of the materials shall be as recommended by the manufacturer for the construction conditions encountered. For used materials or when manufacturer's recommendations are not available or applicable, the allowable working stresses shall be as specified in AASHTO's "Standard Specifications for Highway Bridges."

In general, the interior dimensions of cofferdams shall be sufficient to give clearance for the construction of forms and the inspection of their exteriors and to permit pumping outside of the forms. Cofferdams or cribs that are tilted or moved internally during the process of sinking shall be righted or enlarged to provide the necessary clearance.

When conditions make it impracticable to dewater the foundation before placing the footing, a concrete foundation seal with dimensions as necessary to resist uplift pressures shall be constructed. The concrete for the seal shall be placed as SHOWN ON THE DRAWINGS. The foundation shall then be dewatered and the footing placed. When weighted cribs are employed and the weight is utilized to partially overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level or as otherwise authorized by the Engineer.

Cofferdams shall be constructed to protect recently placed concrete against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. Timber or bracing that extends into substructure masonry shall not be left in cofferdams or cribs.

Pumping from the interior of any foundation enclosure shall be done in a manner that will not carry concrete materials away. All pumping required during the placing of concrete, or for a period of at least 24 hours thereafter, shall utilize a suitable sump located outside the concrete forms. Pumping to dewater a sealed cofferdam shall not start until the seal has set sufficiently to withstand the hydrostatic pressure.

Cofferdams and cribs, and all sheeting and bracing, shall be removed after completion of the substructure. Removal shall not disturb or mar finished structure.

206.06 Preservation of Channel

No excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling. The natural stream bed adjacent to the structure shall not be disturbed without approval of the Engineer. After the foundation base is in place, all excavation or dredging made at the site of the structure before caissons, cribs, or cofferdams were sunk in place shall be backfilled to the original ground surface or streambed with suitable material. Material deposited within the stream area from foundation or other excavation or from the filling of cofferdams shall be removed and the stream area freed from obstructions. Water pumped from foundation excavation shall not be discharged directly into live streams but shall be pumped to settling areas SHOWN ON THE DRAWINGS or approved by the Engineer.

206.07 Backfill & Embankments for Structures

All backfilling and embankment construction within 20 feet of abutments shall be in accordance with this Subsection.

Excavated areas around structures shall be backfilled with approved material placed in horizontal layers, not over 6 inches (loose measure) in depth, to the level of the original ground surface. Each layer shall be compacted in accordance with Subsection 203.15(b), Method 4.

Backfill or embankment material shall be placed simultaneously, when possible, to approximately the same elevation on both sides of abutments, piers, or walls. If conditions require placing backfill or embankment appreciably higher on one side than on the opposite side, the additional material on the higher side shall not be placed until the masonry has been in place 14 days or until laboratory tests establish that the masonry has attained sufficient strength to withstand without damage the pressure created by the methods used and the materials placed.

Backfill or embankment shall not be placed behind the walls of concrete culverts or abutments of rigid frame structures until the top slab has been placed and cured. Backfill and embankment behind abutments held at the top by the superstructure and behind the sidewalls of culverts shall be carried up simultaneously behind opposite abutments or sidewalls.

All embankments adjacent to structures shall be constructed in horizontal layers and compacted in accordance with Subsection 203.15(b). Method 4, except that mechanical tampers may be used for the required compaction. Special care shall be taken to prevent wedging action against the structure. All slopes bounding or within the areas to be backfilled shall be benched or serrated to prevent wedging action. The placing of embankment and the benching of slopes shall maintain a horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled against, except when undisturbed material obtrudes upon the area.

Material for backfilling structures shall be free of excess moisture, muck, frozen material, roots, sod, or other unsuitable material.

Rock having its largest dimension greater than 6 inches shall not be placed within any backfill or embankment that is within 3 feet of the abutments.

206.08 (Reserved)

MEASUREMENT

206.09 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

The volume of excavation will include only the number of cubic yards of material excavated from within the limits hereinafter defined, regardless of whether the excavation is made within a cofferdam enclosure or in an open trench or pit.

The horizontal limits will be the sides of the trench or pit, except that structure excavation will not include material removed outside of vertical planes 18 inches outside of and parallel to the neat lines of the footings. The bottom limits of the excavation shall be the bottom elevation of the footing as SHOWN ON THE DRAWINGS. The upper limit shall be the top surface of the ground or the bed of the stream as it existed prior to the start of construction operations.

PAYMENT

206.10 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS, except that:

(a) Any excavation and related work for footing ordered to extend work more than 5 feet below the footing elevation SHOWN ON THE DRAWINGS will be covered by design change or change order.

(b) Shoring, cribbing, and related work for excavation ordered more than 5 feet below footing design elevation will be paid for as provided in (a) above.

206
.09

Payment shall be made under:

Pay Item		Pay Unit
206(01)	Excavation for________________Structures . . .	C.Y.
206(02)	Excavation for _______________Structures . . .	L.S.
206(03)	Shoring, Cribbing, Cofferdams, and Related Work	L.S.

Section 206A - Excavation for Culverts & Minor Structures

DESCRIPTION

206A.01
Work

This work shall consist of all excavation for foundations of culverts and minor structures, backfilling of completed structures, and disposal of excavated material. The footing for a bottomless arch culvert shall be considered a minor structure.

This work shall include all excavation below the designed slope or subgrade line as SHOWN ON THE DRAWINGS, excavation of unsuitable foundation material, and furnishing and placing approved foundation material.

This work shall also include necessary diverting of live streams, pumping, bailing, draining, sheeting, bracing, and miscellaneous items required for execution of the work.

CONSTRUCTION

206A.02
Clearing & Grubbing

Before starting excavation in any area, all necessary clearing and grubbing in that area shall have been completed in accordance with Section 201.

206A.03
Excavation

Excavation for culverts and foundation pits for minor structures shall be excavated to the lines and grades or elevations SHOWN ON THE DRAWINGS or as DESIGNATED on the ground. Excavations shall be of sufficient size to permit the placing and backfilling of culverts, minor structures, or minor structure footings. Boulders, logs, and any other unsuitable materials encountered shall be removed and disposed of in areas SHOWN ON THE DRAWINGS.

(a) Minor Structures. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface that is level, stepped, or serrated. All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be completed until just before the footing is to be placed. When the foundation material is soft or otherwise unsuitable, it shall be removed and replaced with approved granular material. The contractor shall notify the Engineer when each excavation is completed and will receive written approval of the excavation and the foundation material prior to placing footings.

(b) Culverts. The width of trenches in natural ground shall permit satisfactory joining and thorough tamping of the bedding material under and around the culvert, and shall be at least as wide as the culvert diameter plus 2 feet.

Where culverts are to be placed in trenches excavated in embankments, then the excavation shall be at least as wide as one diameter plus one diameter on each side.

Unsuitable foundation material shall be excavated below the invert of the culvert to an approximate depth of 2 feet and a width of at least the culvert diameter plus 4 feet. Unsuitable material shall be replaced with selected granular foundation material and compacted to obtain a uniform foundation.

Where rock, hardpan, or other unyielding material is encountered, it shall be removed below the foundation grade for a depth of at least 1 foot. The width of the excavation shall be at least 2 feet greater than the outside width of the culvert. This excavated material shall be replaced with selected mineral soil meeting the requirements for backfill in Subsection 603.08 and compacted in accordance with Subsection 603.08.

206A.04
Utilization of Excavated Materials

All suitable excavated material shall be utilized as backfill or embankment. No excavated material shall be placed in live streams. All surplus material shall be disposed of as SHOWN ON THE DRAWINGS. No excavated material shall be deposited in a manner that will endanger the partly finished structure.

206A.05
Backfill & Embankments for Minor Structures Other Than Pipe Culverts

Excavated areas around minor structures shall be backfilled with selected material placed in horizontal layers, not over 6 inches (loose measure) in depth, to the level of the original ground surface. Backfill shall be readily compactible material free of frozen lumps, chunks of highly plastic clay, or other objectionable material. Rocks larger than 3 inches in diameter shall not be used within 1 foot of the structure. Each layer shall be compacted in accordance with Subsection 203.15(b), Method 4.

206A.06
Bedding, Backfill, & Embankment for Pipe Culverts

Bedding, backfill, and embankment for pipe culverts shall be in accordance with Section 603.

206A.07
(Reserved)

MEASUREMENT

206A.08
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Quantities of excavation will include:

(a) For box culverts, headwalls, minor concrete and stone masonry structures, and minor drainage structures other than pipe culverts, measurement will be between vertical planes 18 inches outside the base of the masonry sections SHOWN ON THE DRAWINGS or as DESIGNATED, and between the foundation grade and the natural ground surface.

(b) For pipe culverts, measurement shall be between the original ground surface, and the bottom excavations and to the minimum width required under 206A.03(b) paragraph 1, 2, 3, or 4 as applicable.

PAYMENT

206A.09
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
206A(01)	Minor Structure Excavation	C.Y.
206A(02)	Pipe Culvert Excavation	C.Y.
206A(03)	Bedding Material	C.Y.
206A(04)	Bedding Material	TON
206A(05)	Foundation Material	C.Y.

Section 207 - Developing Water Supply & Watering

DESCRIPTION

207.01
Work

This work shall consist of furnishing, hauling, and applying water.

MATERIALS

207.02
Requirements

Water used in the planting or care of vegetation shall be free of substances injurious to plant life.

Water sources are SHOWN ON THE DRAWINGS. If the contractor elects to obtain water from other sources, the contractor shall be responsible for obtaining the right to use the water, including any royalty costs.

CONSTRUCTION

207.03
Development of
Supply & Access

Developing water supplies and access shall be as SHOWN ON THE DRAWINGS.

207.04
Equipment

Mobile watering equipment shall have watertight tanks of known capacity. Equipment used for dust control and finishing operations of subgrade and surfaces shall provide uniform and controlled application of water without ponding or washing. Positive control of water from the driver's position is required at all times.

MEASUREMENT

207.05
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

The contractor shall furnish calibrated tanks, distributors, or accurate water meters when directed by the Engineer for measurement.

When the SCHEDULE OF ITEMS calls for "Developing Water Supply and Water," the cost of developing the supply shall be included in the unit price for the quantity of water delivered.

"Hauling of Water" will be measured along the shortest feasible route to the nearest water supply, and does not include the cost of developing the supply.

PAYMENT

207.06
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
207(01)	Developing Water Supply	L.S.
207(02)	Water	M. GALS.
207(03)	Water	L.S.
207(04)	Developing Water Supply and Water	M. GALS.
207(05)	Developing Water Supply and Water	L.S.
207(06)	Hauling Water	M. GALS. MI.

Section 212 - Compaction Equipment, Density Control Strips, & Nuclear Testing Devices

DESCRIPTION

212.01
Work

This procedure shall be used to determine density requirements of selected embankments, subgrade, bases, and bituminous concrete. The procedure shall consist of control strip construction to establish target densities and approved roller patterns for the specified course and the use of portable nuclear moisture/density testing equipment to determine in-place densities obtained during the construction process.

CONSTRUCTION

212.02
Compaction Equipment

Compaction equipment shall be capable of obtaining compaction requirements without detrimentally affecting the compacted material. The compacting units may be of any type, provided they are capable of compacting each lift of material as specified and meet the minimum requirements contained herein. Minimum requirements for rollers are as follows:

(a) Sheepsfoot, tamping, or grid rollers shall be capable of exerting a force of 250 pounds per inch of width of roller drum.

(b) Steel-wheel rollers, other than vibratory, shall be capable of exerting a force of not less than 250 pounds per inch of width of the compression roll or rolls.

(c) Vibratory steel-wheel rollers shall have a minimum weight of 6 tons. The compactor shall be equipped with amplitude and frequency controls and specifically designed to compact the material on which it is used.

(d) Pneumatic-tire rollers shall have smooth tread tires of equal size that will provide a uniform compacting pressure for the full width of the roller and capable of exerting a ground pressure of at least 80 psi.

(e) Heavier compacting units may be required to achieve the specified density of the embankment.

212.03
Construction of Control Strips & Determination of Target Density

To determine target density, a control strip shall be constructed at the beginning of work on each type of material to be compacted. Each control strip, constructed to acceptable density and surface tolerances, shall remain in place and become a section of the completed roadway. Unacceptable control strips shall be corrected or removed and replaced at the contractor's expense. A control strip shall have an area of approximately 400 square yards and shall be of the same depth specified for the construction of the course that it represents.

The materials used in the construction of the control strip shall meet the specification requirements. They shall be furnished from the same source and shall be of the same type and moisture content used in the remainder of the course represented by the control strip.

The base upon which a control strip is to be constructed will be approved by the Engineer before placing control strip material.

The equipment used in the construction of the control strip will be approved by the Engineer and shall be of the same type and weight as that to be used on the remainder of the course represented by the control strip.

Compaction of control strips shall commence immediately after the course has been placed to the specified thickness and shall be continuous and uniform over the entire surface. Compaction of the control strip shall be continued until no discernable increase in density can be obtained by additional compactive effort.

Upon completion of the compaction, the mean density of the control strip will be determined by averaging the results of 10 nuclear density tests taken at randomly selected sites within the control strip. The mean density of the control strip shall be the target density for the remainder of the course that it represents.

If the mean density of the control strip is less than 95 percent of the maximum density as determined in the laboratory compacted specimens, the Engineer may request the construction of another control strip. The test procedure used to establish the maximum density will be SHOWN ON THE DRAWINGS.

A new control strip may also be requested by the Engineer or by the contractor when:

(a) A change in the material or job mix formula is made.

(b) Ten days of production have been accepted without construction of a new control strip.

(c) There is reason to believe that a control strip density is not representative of the material being placed.

212.04
Control of
Compaction

The specified course shall be compacted to at least 95 percent of the target density. Density will be tested by a portable nuclear moisture-density test device in accordance with AASHTO T 238 and T 239.

MEASUREMENT

212.05
Method

No separate measurement will be made for this item.

PAYMENT

212.06
Basis

The cost of construction control strips will be included in the payment of other items of work.

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SECTION 550 BRIDGE CONSTRUCTION

550

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Section 551 - Piling

DESCRIPTION

551.01
Work

This work shall consist of furnishing and driving or placing piling.

The contractor shall furnish the piles in accordance with an itemized list that will be furnished by the Engineer, showing the number and lengths of all piles. No list will be furnished when cast-in-place concrete piles are specified. When test piles and load tests are required in accordance with Subsections 551.02 and 551.03, respectively, the data obtained from driving test piles and making load tests will be used in conjunction with other available subsoil information to determine the number and lengths of piles to be furnished. The Engineer will not prepare the itemized list of piles for any portion of the foundation area until all required load tests and test pile driving in that portion have been completed.

Lengths of piles given in the order list will be based on the lengths that are assumed to remain in the completed structure. The contractor shall, without added compensation, increase the lengths to provide for fresh heading and for such additional length as might be necessary to suit the contractor's method of operation.

551.02
Test Piles

For information, the contractor may drive as many test piles as necessary. When called for in the SCHEDULE OF ITEMS or when needed for calibrating hammers in accordance with Subsection 551.03, the contractor shall furnish and drive test piles of the dimensions and at the locations SHOWN ON THE DRAWINGS or ordered by the Engineer. They shall be of the material shown in the SCHEDULE OF ITEMS and shall be driven to refusal or to such tip elevation or approximate bearing value SHOWN ON THE DRAWINGS or ordered by the Engineer. When test piles are to be incorporated in the completed structure, they shall be driven with the same type of hammer that will be used for driving the contract piles.

When the Engineer requests a load test to determine a bearing value, the first load test pile shall be driven to the specified bearing value as determined by the applicable formula indicated in Subsection 551.04. Subsequent test piles to be load tested shall be driven to the specified bearing values as determined by the applicable formula modified by the results of prior load tests and foundation data. It is the intent of these specifications that test piles to be load tested shall fail between two and three times the specified bearing value except for piles driven to refusal, rock, or a specified tip elevation. The ground at each test pile shall be excavated to the elevation at the bottom of the footing before the pile is driven. The hammer used shall meet the requirements of Subsection 551.16.

551.03
Load Tests

When called for in the SCHEDULE OF ITEMS, load tests shall be made where SHOWN ON THE DRAWINGS or required in the SPECIAL PROJECT SPECIFICATIONS. When diesel or other types of hammers requiring calibration are to be used, the contractor shall make load tests even though no load tests are called for in the SCHEDULE OF ITEMS, except that load tests will not be required when the hammer is to be used only for driving piles to refusal, rock, or a fixed tip elevation, or when the hammer is of a type and model that has been previously calibrated for similar type, size, and length of pile, and foundation material. Calibration data must have been obtained from sources acceptable to the Engineer.

Load tests shall be made by methods approved by the Engineer. The contractor shall submit to the Engineer for approval detailed drawings of the loading apparatus he intends to use. The apparatus shall be constructed to allow the various increments of the load to be placed gradually without causing vibration to the test piles. If the approved method requires the use of tension (anchor) piles, such tension piles shall be of the same type and size as the permanent piles and shall be driven in the location of permanent piles when feasible. Permanent piling used as anchor piling that is raised during the load test shall be redriven to original grade and bearing.

After the completion of load tests, the load used shall be removed, and the piles, including tension piles, shall be used in the structure if they are found by the Engineer to be satisfactory for such use. Test piles not loaded shall be used similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for use in the structure, it shall be removed or cut off at least 1 foot below the ground line or footings, whichever is applicable.

551.04 Timber Pile Bearing Values by Formula

When load tests are called for in the SCHEDULE OF ITEMS, and when diesel or other hammers to be calibrated are used, the minimum number of hammer blows per unit of pile penetration needed to obtain the specified bearing value of piles will be determined by load tests in accordance with Subsections 551.02 and 551.03. In the absence of load tests, the safe bearing value of each timber pile will be determined by whichever of the following approximate formulas is applicable.

For gravity hammers:

$$P = \frac{2WH}{S + 1}$$

For single-acting steam or air hammers and for diesel hammers having unrestricted rebound of ram:

$$P = \frac{2WH}{S + 0.1}$$

For double-acting steam or air hammers and diesel hammers having enclosed rams:

$$P = \frac{2E}{S + 0.1}$$

where

P = *safe load per pile in pounds;*

W = *weight of the striking part of the hammer in pounds;*

H = *height of fall in feet for gravity, steam, and air hammers; and observed average height of fall, in feet, of blows used to determine penetration for diesel hammers with unrestricted rebound of ram;*

S = *average penetration per blow in inches for the last 5 to 10 blows of a gravity hammer or the last 10 to 20 blows of a steam, air, or diesel hammer; and*

E = *the manufacturer's rating for foot-pounds of energy developed by double-acting steam or air hammers; and*

= *90 percent of the average equivalent energy in foot-pounds as determined by gauge attached to the pile hammer and recorded during the period when the average penetration per blow is recorded for diesel hammers having enclosed rams. Hammers of this type shall be equipped with a gauge, and applicable charts shall be supplied that will evaluate the equivalent energy being produced under any driving condition.*

The above formulas are applicable only when:

(a) The hammer has a free fall.

(b) The head of the pile is free from broomed or crushed wood fiber or other serious impairment.

(c) The penetration is at a reasonably quick and uniform rate.

(d) There is no measurable bounce after the blow.

(e) If a gravity hammer is used, its weight shall be at least 3,000 pounds and equal to or greater than the weight of the pile plus the weight of the driving head, but shall not be greater than three times the weight of the pile.

(f) A follower is not used.

If there is a measurable bounce, twice the height of bounce shall be deducted from H to determine the value in the formula. The bearing power as determined by the appropriate formula in the foregoing list will be considered effective only when it is less than the crushing strength of the pile.

In all cases, when bearing power is determined by a formula, timber piles shall be driven until the computed safe bearing power of each is not less than the design value SHOWN ON THE DRAWINGS. Piles shall be driven to a pile tip elevation at least as low as SHOWN ON THE DRAWINGS.

551.05 Concrete & Steel Pile Bearing Values

The formulas specified above for timber piling may be used to approximate the bearing value of precast concrete piles, cast-in-place concrete piles, and structural steel piles.

Wave Equation Analysis. Wave Equation Analysis shall be used to determine pile bearing values when specified in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS. When wave equation analysis is specified, all pile driving equipment to be used in the work shall be subject to approval by the Engineer. Prerequisite to the Engineer's approval, the contractor shall submit the following:

(a) The pile hammer operating specifications. The specifications shall include the weight, diameter, and length of the ram; drive head and anvil (if applicable) dimensions and weights; capblock and cushion data (such as material thickness, area, modulus of elasticity, and coefficient of restitution); net weight of hammer, net weight of cylinder, and piston areas for doubleacting or differential acting air or steam hammers; bounce chamber pressure versus equivalent energy graphs for closed-end diesel hammers; and mandrel type and weight, when applicable.

(b) A wave equation analysis bearing the approval of a registered professional engineer for each hammer proposed for use to determine the soil resistance value SHOWN ON THE DRAWINGS unless otherwise provided in the SPECIAL PROJECT SPECIFICATIONS.

The pile hammer operating specifications and wave equation analysis shall be submitted to the Engineer at least 21 days prior to commencing pile driving operations. The Engineer will approve or deny the submittal within 7 days of receipt from the contractor.

Approval of the proposed pile hammer shall not relieve the contractor of responsibility for stress-damaged piles due to misalignment of the leads, failure of capblock or cushion material, failure of splices, malfunctioning of the pile hammer, or other improper construction methods. Piles damaged for such reasons shall be rejected if the damage impairs the strength of the pile as determined by the Engineer.

In all cases where the bearing value of concrete and steel piles is determined by formula, the piles shall be driven until the safe bearing value of each is computed to be not less than the design value SHOWN ON THE DRAWINGS. Piles shall be driven to a tip elevation at least as low as SHOWN ON THE DRAWINGS.

551.06 Minimum Penetration

All piles shall penetrate at least 10 feet into the natural ground, and when a pile tip elevation is specified shall penetrate at least to the specified tip elevation. When the blow count approaches refusal without reaching the required penetration, additional aids shall be used to obtain the specified penetration, unless otherwise permitted in writing by the Engineer. These aids may include the use of waterjets or larger hammer and ram striking with low velocity. Driving equipment that damages the pile shall not be used.

551.07 Jetted Piles

The safe bearing value of jetted piles will be determined by actual tests or by the appropriate method and formulas given above. No jet shall be used during the test blows.

MATERIALS

551.08 Requirements

Materials for piling shall meet the requirements of the following Subsections:

Untreated Timber Piles	715.01
Treated Timber Piles	715.02
Concrete Piles	552.03-04
Steel Shells	715.04
Steel Pipes	715.05
Steel H-Piles	715.06
Sheet Piles	715.07
Pile Shoes	715.08
Paint	708.03
Reinforcing Steel	709.01
Prestessing Reinforcing Steel	709.03

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CONSTRUCTION

551.09 Precast Concrete Piles

Precast concrete piles shall be of the design or designs SHOWN ON THE DRAWINGS. They shall be constructed of Portland cement concrete meeting the requirements of Section 552. Prestressed concrete piles shall be prestressed in accordance with Section 553.

The piles shall be cast separately or if alternate piles are cast in a tier, the intermediate piles shall not be cast until 4 days after the adjacent piles have been poured. Piles cast in tiers shall be separated by tar paper or other suitable separating materials. The concrete in each pile shall be placed continuously. The completed piles shall be free from stone pockets, honeycombs, or other defects, and shall be straight and true to the form specified. The forms shall be true to line and built of metal, plywood, or dressed lumber. A 1-inch chamfer strip shall be used in all corners unless otherwise SHOWN ON THE DRAWINGS. Forms shall be watertight and shall not be removed until at least 24 hours after the concrete is placed. Exposed surfaces of piles shall be given a Class 1 ordinary surface finish. Piles shall be cured and finished in accordance with the applicable requirements of Section 552 or 553.

Test cylinders shall be made in accordance with AASHTO T 23 and tested for compressive strength in accordance with AASHTO T 22.

Piles shall not be moved until the tests indicate a compressive strength of 80 percent of the required 28-day compressive stength, and they shall not be transported or driven until the tests indicate a compressive strength of the required 28-day compressive strength.

When concrete piles are lifted or removed, they shall be supported at the points SHOWN ON THE DRAWINGS or, if not so shown, they shall be supported at the quarter points.

551.10
Cast-In-Place Concrete Piles

Cast-in-place concrete piles shall be of the design or designs SHOWN ON THE DRAWINGS. They shall consist of concrete cast-in-steel shells or pipes driven to the required bearing. Concrete shall meet the requirements of Section 552.

The inside of shells and pipes shall be cleaned and all loose material removed before concrete is placed. The concrete shall be placed in one continuous operation from tip to cutoff elevation avoiding segregation. The top 15 feet of concrete-filled shells shall be consolidated by vibratory equipment.

Pipes shall be of the diameter SHOWN ON THE DRAWINGS. The wall thickness for shell pipes shall not be less than that SHOWN ON THE DRAWINGS but in no case less than 16 gauge (0.064 inch). The pipe, including end closures, shall be of sufficient strength to be driven by the specified methods without distortion.

Closure plates and connecting welds shall not project more than 1/2 inch beyond the perimeter of the pile tips.

Shells or pipes shall not be filled with concrete until all adjacent shells, pipes, or piles within a radius of 15 feet have been driven to the required resistance, or until all shells or pipes for any one bent or abutment have been completely driven.

No shell, pipe, or pile shall be driven within 20 feet of a shell or pipe that has been filled with concrete until at least seven days have elapsed.

551.11
Steel H-Piles

Steel H-piles shall consist of structural steel shapes of the sections SHOWN ON THE DRAWINGS.

When placed in the leads, the pile shall not exceed the camber and sweep permitted by allowable mill tolerance. Piles bent or otherwise damaged will be rejected.

The loading, transporting, unloading, storing, and handling of steel H-pile shall be conducted so that the metal will be kept free from damage.

551.12
Open End Tubular Steel Piles

Piles with an outside diameter of less than 14 inches shall have a minimum wall thickness of 1/4 inch. Piles with an outside diameter of 14 inches and greater shall have a minimum wall thickness of 3/8 inch. The pipe shall be of sufficient strength to be driven by the specified methods without distortion.

551.13
Timber Piles

(a) General. The heads of treated timber piles shall be shaped to fit the driving head.

(b) Strapping. Treated timber piles shall be strapped with a minimum of three straps: one approximately 18 inches from the butt, one approximately 24 inches from the butt, and one approximately 12 inches from the tip. In addition, piles shall be strapped at an interval not to exceed 15 feet. Straps shall be approximately 1.25 inches wide, 0.03 inch thick, and manufactured from cold-rolled, heat-treated steel. The strap shall have an ultimate tensile strength of 5,100 pounds. The strap shall encircle the pile once and shall be fastened with a clip so crimped that the joint will have a minimum tensile strength of 80 percent of the tensile strength of the strap. The strap shall be installed after pressure treating of the pile.

(c) Storage and Handling of Timber Piles. The method of storage and handling shall be such as to avoid injury to the piles. Special care shall be taken to avoid breaking of the surface of treated piles. Cuts or breaks in the surface of treated piles shall be protected in accordance with AWPA Standard M-4. If the treatment is damaged so that the integrity of the pile is in jeopardy, the pile will be rejected and a replacement pile shall be furnished by the contractor at no expense to the Government.

(d) Minimum Diameter. The minimum diameter of timber piling shall be as SHOWN ON THE DRAWINGS.

551.14
Extensions

Extensions, when approved by the Engineer, shall be made in accordance with this Subsection.

(a) Precast Concrete Piles. Extensions of precast concrete piles shall be made by cutting away the concrete at the end of the pile, leaving the reinforcement steel exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement of the same size as used in the pile shall be fastened securely to the projecting steel and the necessary form work shall be placed. Care shall be taken to prevent leakage along the pile. Just prior to placing concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement, or other bonding material. The forms shall remain in place until the concrete has attained at least two-thirds of its required strength. If tests are not available, forms shall remain in place until the concrete is set and will not be damaged, but not less than 7 days. Curing and finishing operations shall be in accordance with Sections 552 and 553.

(b) Prestressed Piles. Extensions of prestressed precast piles will generally not be permitted, but when permitted they shall be made in accordance with (a) above, but only after driving has been completed. Reinforcement bars shall be included in the pile head for splicing to the extension bars. No additional driving will be permitted. The contractor has the option of submitting alternative plans of extensions for approval by the Engineer.

(c) Steel H-Piles, Pipes, Shells, and Open-End Tubular Steel Pipes. If the ordered length of a steel H-pile, pipe, or open-end tubular steel pile shell is insufficient to obtain the specified bearing value, an extension of the same cross section shall be spliced to it. Unless otherwise SHOWN ON THE DRAWINGS, splices shall be made by butt-welding the entire cross section, using the electric arc method in accordance with current AWS specifications. Butt-welded surfaces shall be flat or concave. Every effort shall be made to have welds below ground. Where exposed in pile bents, welds exceeding 1/16 inch in thickness above the base metal shall be ground off.

551.15
Timber Pile Bents

Piles for any one bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. However, care shall be exercised in the distribution of piles of various sizes to obtain uniform strength and rigidity in the bents of any given structure.

Cutoffs shall be made accurately to ensure full bearing between caps and piles of bents.

551.16
Driving Piles

At least 21 days before first use of any pile hammer, the contractor shall furnish the Engineer two copies of the manufacturer's specifications on the hammer. The specifications shall include all information necessary to properly use the appropriate bearing value formula in Subsection 551.04 and to verify that the hammer meets the other requirements of this Section. All piles shall be driven at locations SHOWN ON THE DRAWINGS. They shall be driven within an allowed variation of 1/4 inch per foot of pile length above the ground from the vertical or batter SHOWN ON THE DRAWINGS. The maximum allowable variation from the pile design location and batter shall be as SHOWN ON THE DRAWINGS.

Prior to driving piles, all structure excavation shall have been performed in accordance with Sections 203 and 206.

Predrilled holes to facilitate pile-driving operations shall be provided to the diameter and depths SHOWN ON THE DRAWINGS when required by the SPECIAL PROJECT SPECIFICATIONS. The diameter of the holes shall not be greater than 0.8 times the diameter of the piles unless permitted by the Engineer.

The heads of all piles shall be protected by caps of approved design, having a rope or other suitable cushion next to the pile head and fitting into a casting, which in turn supports a timber shock block.

For special types of piling, driving heads, mandrels, or other devices meeting the manufacturers' recommendations shall be provided so the pile can be driven without damage.

For steel piling, the heads shall be cut squarely and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer.

Full-length piles shall be used except when splices are permitted as provided by Subsection 551.14.

Piles shall be driven with steam, air, diesel hammers, or a combination of hammers with water jets. Gravity or drop hammers are permitted when driving timber piles unless excluded ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The boiler or tank shall be equipped with an accurate pressure gauge, and another gauge shall be supplied at the hammer intake to determine the drop in pressure between the gauges.

Gravity hammers permitted for driving timber piling shall weigh not less than the combined weight of the driving head and pile, nor less than 3,000 pounds. When gravity hammers are permitted for driving timber piles, the drop of the hammer should be regulated to avoid damage to the pile.

Pile hammers, except gravity or drop hammers, shall be steam, air, or diesel hammers that develop sufficient energy to drive the piles at a penetration rate of not less than 1/8 inch per blow at the required bearing value. When steam, air, or diesel hammers are used, the total energy developed by the hammer shall be not less than 7,000 foot-pounds per blow, except as specified below for concrete piles.

Diesel hammers shall be operated with wide-open throttles when blows are being counted for determination of penetration for use in the safe load formula, except that in the case of diesel hammers with enclosed rams, the throttle settings shall be just short of the settings that would cause nonstriking parts of the hammers to rise off the piles as the ram piston travels upward.

Piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed to afford freedom of movement of the hammer, and they shall be held in position by guys or steel braces to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary and shall be designed to permit proper placing of batter piles. The driving of piles with followers shall be allowed only with written approval from the Engineer.

Steam, diesel, or air hammers used for driving concrete piles shall develop an energy per blow at each full stroke of the piston of not less than 3,500 foot-pounds per cubic yard of concrete in the pile driven.

No driving of piles shall be done within 20 feet of concrete less than 7 days old.

551.17
Defective Piles

The method used in driving piles shall not produce crushing and spalling of the concrete, injurious splitting, splintering, and brooming of the wood, or deformation of the steel. Excessive manipulation of piles to force them into proper position will not be permitted. Any pile damaged by reason of internal defects, or by improper driving, or driven out of its proper location, or driven below the elevations SHOWN ON THE DRAWINGS or set by the Engineer, shall be corrected by the contractor, without added compensation, by one of the following methods approved by the Engineer for the pile in question:

(a) The pile shall be withdrawn and replaced by a new and, when necessary, longer pile.

(b) A second pile shall be driven adjacent to the defective pile.

(c) The pile shall be spliced or built up as otherwise provided herein or a sufficient portion of the footing extended to properly embed the pile. Piles shall not be spliced unless approved by the Engineer. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

A concrete pile will be considered defective if it has a visible crack, or cracks, extending around the entire periphery of the pile or any defect that affects the strength or life of the pile.

551.18
Cutting Off & Capping Piles

Piles shall be cut off level at the elevation SHOWN ON THE DRAWINGS. The length of pile cutoff shall be sufficient to permit the removal of all injured material. The distance from the side of any pile to the nearest edge of the footing shall be a minimum of 9 inches.

When the cutoff elevation for a precast concrete pile or for the steel shell or concrete casing for a cast-in-place concrete pile is below the elevation of the bottom of the cap, the pile shall be built up from the butt of the pile to the elevation of the bottom of the cap by means of a reinforced concrete extension as approved by the Engineer. Steel shells or concrete casings for cast-in-place concrete piles shall be cut off at the DESIGNATED elevation before being filled with concrete.

Cutoffs of steel bearing piles shall be made at right angles to the axis of the pile. The cuts shall be made in clean, straight lines.

Cutoffs of treated timber piles shall be protected in accordance with AWPA Standard M-4.

At the completion of the work, all unused pile cutoff lengths not included in the itemized order list furnished by the Engineer shall become the property of the contractor and shall be removed or disposed of by the contractor.

551.19
Protecting Untreated Timber Trestle Piles

The sawed surface of the heads of untreated piles shall be thoroughly brush coated with two applications of hot creosote oil or other approved preservative.

551.20
Painting Steel Piles

When steel piles extend above the ground surface or water surface, they shall be protected by three coats of paint in accordance with the systems for cleaning and painting metal surfaces in Section 555 as SHOWN ON THE DRAWINGS. This protection shall extend from the elevation SHOWN ON THE DRAWINGS to the top of the exposed steel.

MEASUREMENT

551.21
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

551.22
Timber, Steel, & Precast Concrete Piles

(a) Piles Furnished. Measurement (in feet) will be the sum of the lengths, measured to the nearest foot, of the several types and lengths of piles furnished and stockpiled in good condition at the site of the work by the contractor and accepted by the Engineer. The number of feet to be measured will include the lengths of test and tension piles required, but not the lengths of those furnished at the contractor's option. No measurement will be made for footage of piles, including test piles, furnished by the contractor to replace piles previously accepted by the Engineer that are lost or damaged while in stockpile or during handling or driving, prior to completion of the contract and which are subsequently removed from the site of the work or disposed of otherwise.

If case extensions of piles are necessary, the extension length will be included in the linear footage of piling furnished, except for cutoff lengths used for extensions and otherwise measured for payment.

(b) Piles Driven. Driving of timber, steel, and precast concrete piles will be measured to the nearest foot of piling in place between the actual tip elevation and the elevation of the ground existing at the pile immediately prior to driving. Structure excavation, if required, shall have been performed prior to this measurement. Test piles driven at the option of the contractor will not be included unless they comply fully with the requirements specified herein and are accepted by the Engineer to become part of the completed structure.

Drilled or jetted holes for facilitating pile driving procedures will not be measured directly, but will be considered incidental to pay items on the SCHEDULE OF ITEMS.

551.23
Cast-In-Place Concrete Piles

Cast-in-place piles will be measured by the actual number of feet of piles cast and left in place in the completed and accepted work. Measurement to the nearest foot will be made from the point of the tip of the pile to the bottom of the cap or bottom of the footing, as the case may be. Portions of piles cast deeper than required will not be measured.

551.24
Pile Shoes

Pile shoes, including test pile shoes, will be measured as the number of pile shoes SHOWN ON THE DRAWINGS or ordered in writing by the Engineer, furnished and stockpiled by the contractor in good condition at the site of the work, and accepted by the Engineer. Pile shoes furnished at the contractor's option will not be included. No allowance will be made for pile shoes furnished by the contractor to replace pile shoes previously furnished and accepted by the Engineer that are lost or damaged while in stockpile or during handling prior to completion of the contract and which are subsequently removed from the site of the work or disposed of otherwise.

551.25
Load Tests

Load tests will be measured by the number of load tests completed and accepted. Load tests made at the option of the contractor and load tests made to calibrate diesel or other designated types of hammers will not be included in the quantity measured.

551.26
Splices

Splices for pipes, shells, or H-piles will be measured by the number of splices ordered and accepted by the Engineer. Splices made for the convenience of the contractor will not be measured.

PAYMENT

551.27 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
551(01)	Untreated Timber Piles, Furnished	L.F.
551(02)	Treated Timber Piles, _____ Preservative, Furnished	L.F.
551(03)	Steel H-Piles, Furnished	L.F.
551(04)	Precast Concrete Piles, Furnished	L.F.
551(05)	Precast Prestressed Concrete Piles, Furnished	L.F.
551(06)	Untreated Timber Sheet Piles, Furnished	L.F.
551(07)	Treated Timber Sheet Piles, _____ Preservative, Furnished	L.F.
551(08)	Precast Concrete Sheet Piles, Furnished	L.F.
551(09)	Steel Shells for Concrete Piles, Furnished	L.F.
551(10)	Steel Pipes for Concrete Piles, Furnished	L.F.
551(11)	Untreated Timber Piles, Driven	L.F.
551(12)	Treated Timber Piles, Driven	L.F.
551(13)	Steel H-Piles, Driven	L.F.
551(14)	Precast Concrete Piles, Driven	L.F.
551(15)	Untreated Timber Sheet Piles, Driven	L.F.
551(16)	Treated Timber Sheet Piles, Driven	L.F.
551(17)	Precast Concrete Sheet Piles, Driven	L.F.
551(18)	Precast Prestressed Concrete Piles, Driven	L.F.
551(19)	Test Piles, ______________________, Driven	L.F.
551(20)	Concrete Piles Cast in Steel Shells, Driven	L.F.
551(21)	Concrete Piles Cast in Steel Pipes, Driven	L.F.
551(22)	Pile Shoes	EA.
551(23)	Splices	EA.
551(24)	Load Tests	EA.

Section 552 - Structural Concrete

DESCRIPTION

552.01
Work

This work shall consist of furnishing, placing, and finishing concrete in major structures. Concrete shall consist of a mixture of Portland cement or fly ash modified Portland cement, fine aggregate, coarse aggregate, admixtures when required, and water mixed in the proportions approved by the Engineer.

552.02
Classes, Composition, & Testing of Concrete

(a) Classes of Concrete. The class of concrete used in each part of the structure shall be as SHOWN ON THE DRAWINGS or approved by the Engineer.

Prestressed concrete shall be Class P. Concrete deposited under water shall be seal concrete. All other concrete shall be Class A and shall be air entrained.

(b) Composition of Concrete. The contractor, through an approved testing laboratory, shall design the mix for each class of concrete. The mix design proposed by the contractor shall meet the requirements in table 552-1 and the minimum strength requirements SHOWN IN THE DRAWINGS, in the SPECIAL PROJECT SPECIFICATIONS, or in Subsection 552.02(c). The testing laboratory engaged by the contractor shall be fully equipped and capable of performing the required tests and services. The mix design shall be based on representative samples of aggregates, cement, water, and admixtures to be used on the project. Aggregate samples shall be taken in accordance with AASHTO T 2 and reduced to testing size in accordance with AASHTO T 248. A separate proposed mix design for each class of concrete shall be submitted to the Engineer for review at least 21 days prior to placement of the concrete in the work. If the contractor elects to change aggregate source during the progress of work, new mix designs meeting these requirements shall be submitted to the Engineer at least 21 days before such material is to be placed in the work.

Where fly ash modified concrete is used, the water/cement ratio in table 552-1 shall be computed as the ratio of the weight of water to the combined weights of Portland cement and 60 percent of the weight of the fly ash.

Current mix designs for other projects may be acceptable provided all items required herein are covered by certified submittals. Mix-design and aggregate quality tests from other projects shall have been run within 12 months of the date of submittal, and the aggregate source must be the same.

Table 552-1.--Classes of structural concrete--requirements.

Class of Concrete	Method of Placing	Minimum Cement Content Required (Pounds per cu yd)	Maximum Water/ Cement Ratio Allowed (Pounds per Pound)	Required Slump (Range) (Inches)	Required Entrained Air (Range) (Percent)
A[b]	Vibrated	611	0.49	2-1/2 (±1)	5(±1)
P[b]	Vibrated	658	0.44	2(±1)	-- --[a]
Seal	Nonvibrated	658	0.54	6(±2)	-- --

[a] Concrete used in prestressed concrete sections shall not be air-entrained unless SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

[b] Designated by 28-day compressive strength SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. See Subsection 552.02(c) for minimum strength requirements.

Each mix design shall include the following items:

(1) Location and identification of aggregate source.

(2) Batch quantities for 1 cubic yard of concrete, including:

a. Weight in pounds of fine aggregate in the saturated surface dry condition.

b. Weight in pounds of each coarse aggregate size in the saturated surface dry condition.

c. Weight in pounds of cement.

d. Weight in pounds and volume in gallons of water and the water/cement ratio in pounds per pound.

e. Amount and description (include manufacturer, specific product name, and number) of all admixtures, including fly ash.

(3) Test results on the proposed mix design, including the following:

a. Cement factor in pounds per cubic yard based on yield test.

b. Water/cement ratio expressed in pounds of water per pound of cement (aggregates in saturated surface dry condition).

c. Percent entrained air by volume.

d. Consistency in inches of slump.

e. At least three 7-day and three 28-day compressive strength tests.

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(4) Brand, type, and place of manufacture of cement.

(5) Aggregate test results for grading, deleterious substances, and physical properties shall be in accordance with Section 703. In addition to the requirements of Section 703, bulk specific gravity and absorption of coarse and fine aggregate shall be given. Unless waived in writing by the Engineer, the following test results shall be submitted.

Fine Aggregate

a.	Sieve analysis	AASHTO T 27
b.	Fineness modulus	AASHTO M 6
c.	Deleterious substances	
	Clay lumps and friable particles	AASHTO T 112
	Material finer than the No. 200 Sieve . . .	AASHTO T 11
	Coal and lignite, as defined in 7.1.6 of AASHTO M 80	AASHTO T 113
	Organic impurities	AASHTO T 21
d.	Evaluation of potential aggregate reactivity	AASHTO M 80
e.	Bulk specific gravity and absorption capacity	AASHTO T 84
f.	Sand Equivalent (min. 75)	AASHTO T 176

Coarse Aggregate

a.	Sieve analysis	AASHTO T 27
b.	Deleterious substances	
	Clay lumps and friable particles	AASHTO T 112
	Chert--less than 2.4 sp. gr. SSD	AASHTO T 113
	Material finer than the No. 200 sieve . .	AASHTO T 11
	Coal and lignite, as defined in 7.1.6 of AASHTO M 80	AASHTO T 113
c.	Evaluation of potential aggregate reactivity	AASHTO M 80
d.	Percentage of wear (L.A.R.)	AASHTO T 96
e.	Unit weight of aggregate	AASHTO T 19
f.	Bulk specific gravity and absorption capacity	AASHTO T 85

(c) Concrete Compressive Strength. Unless otherwise SHOWN ON THE DRAWINGS, the specified minimum 28-day compressive strength in pounds per square inch for the given classes of concrete shall be the following:

Specified Strength

Class	At Time of Transfer of Prestress Force (Minimum)	7-Day (Minimum)	28-Day (Minimum)
A	-----	2,300	3,500
P	4,500	-----	5,500
P (air-entrained)	4,500	-----	5,000
Seal	-----	2,000	3,000

For a strength test, two standard test specimens shall be made. For each structural element, enough specimens shall be taken to make at least one 7-day strength test and one 28-day strength test (total four specimens, minimum). The test result shall be the average of the strengths of the two specimens, except that if any specimen shows definite evidence, other than low strength, of improper sampling, molding, handling, curing, or testing, it shall be discarded, and the strength of the remaining cylinder shall be considered the test result.

The standard 28-day curing period for compressive strength tests shall be extended for fly ash modified concrete by 1 day (rounded to the nearest whole day) for each 1.5 percent of Portland cement replaced with fly ash at the selected rate. (Example: If the maximum of 20 percent cement is replaced, the curing period for cylinders would be 41 days.)

Prior to approval of the contractor's mix design, or approval of subsequent revised mix design(s), sampling and testing shall be the responsibility of the contractor. Field sampling and testing on the concrete being placed in the work will be made by the Engineer.

The average of all the strength tests representing the concrete in each structural element shall meet the following requirements:

(1) If seven or more strength tests are available, not more than 20 percent of the strength tests shall have values less than the specified strength, and the average of any six consecutive strength tests shall be equal to or greater than the specified strength.

(2) If six or fewer strength tests are available, the average of all the tests shall be equal to or greater than those shown in the following table:

Number of Strength Tests	Required Average Strength (Percent of Specified Strength)	
	Class A & Seal	Class P
1	79	86
2	90	97
3	94	102
4	97	105
5	99	107
6	100	108

(3) If the concrete strength tests fail to meet the requirements of this specification, the Engineer may order the contractor to have a testing laboratory, acceptable to the Forest Service, take and test core samples of questionable concrete. The Engineer may order all low-strength concrete removed and replaced if core strengths are below specified strengths. All costs connected with concrete coring and removal and replacement of concrete that fails to meet these requirements shall be borne by the contractor.

(d) Field Adjustment of Concrete Mix. Field adjustment of the concrete mix designs will be necessary to compensate for the free water content in the aggregates.

After initial mixing, if the consistency (slump) is outside the specification limits (table 552-1) by less than 1 inch, the Engineer may approve the addition of water or cement provided all the following conditions are met:

(1) Addition of Water.

a. The maximum allowable water content in pounds per cubic yard of concrete (table 552-1) is not exceeded.

b. The maximum allowable mixing time (or number of drum revolutions) is not exceeded.

c. Concrete is remixed for at least half of the minimum mixing time (or number of drum revolutions).

(2) Addition of Cement.

a. Amount of cement added does not exceed 94 pounds per cubic yard more than the mix design or a total of 705 pounds per cubic yard, unless otherwise specified in the SPECIAL PROJECT SPECIFICATIONS.

b. The maximum allowable mixing time (or number of drum revolutions) is not exceeded.

c. Concrete is remixed for at least half of the minimum mixing time (or number of drum revolutions).

d. Cement may not be added to Class P concrete.

(3) Adjustment for Variation in Yield. If the cement content of the concrete varies more than 19 pounds per cubic yard over the value in the approved mix design, the proportions may be adjusted at the request of the contractor. If the cement content varies more than 19 pounds per cubic yard below the value in the approved mix design, the proportions shall be adjusted. Adjustment of aggregate weights within the 2 percent allowed by the specification is the only adjustment of the proportions that shall be carried out in the field. Other adjustments of proportions shall be effected by the contractor obtaining a new mix design and securing approval of the new mix design from the Engineer.

(4) Adjustment for Percent Entrained Air. The amount of air-entraining admixture used in each batch will be varied as necessary from that given in the approved mix design to produce concrete having the percent entrained air specified in table 552-1.

(5) Concrete Test Methods. The following methods shall be used in making the indicated tests on concrete:

Making and curing concrete compression test specimens in the laboratory	AASHTO T 126
Sampling fresh concrete	AASHTO T 141
Coring concrete and testing drilled concrete cores	AASHTO T 24
Yield, cubic feet per batch; and cement content, pounds per cubic yard	AASHTO T 121
Percent entrained air (pressure method)	AASHTO T 152
(volume measure)	AASHTO T 196
Compressive strength of concrete cylinders	AASHTO T 22
Flexural strength of concrete	AASHTO T 97
Consistency (slump) of concrete	AASHTO T 119
Making and curing concrete compressive and flexural strength test specimens in the field	AASHTO T 23

MATERIALS

552.03 Requirements

Materials shall meet the requirements of the following Subsections:

Portland Cement	701.01
Fine Aggregate	703.01
Coarse Aggregate	703.02
Joint Fillers	705.01
Curing Materials	711.01
Air-Entraining Admixtures	711.02
Chemical Admixtures	711.03
Water	712.01
Fly Ash	712.14
Epoxy Resin Adhesives	712.10
Bonding Agents	712.12
Elastomeric Bearing Pads	717.13
Elastomeric Compression Joint Seals	717.18

552.04 Cement

Type II cement shall be used for all classes of concrete with the following exceptions:

(a) Type III cement may be used.

(b) When concrete work is permitted by the Engineer in air temperatures below 35 °F, Type III cement shall be used.

(c) Type I cement may be used if SHOWN ON THE DRAWINGS or specified in the SPECIAL PROJECT SPECIFICATIONS.

(d) Pozzolan (fly ash) concrete may be proposed for any mix design except for prestressed concrete, either pretensioned or posttensioned. If fly ash is proposed as an additive to a mix design containing Type I, II, or III cement. the fly ash shall be substituted for cement at a rate of 1.2 pounds of fly ash for 1.0 pounds of Portland cement. After substitution, design aggregate volumes shall be reduced by an amount equal to the net increase in volume of the combined cement and fly ash. Not less than 10 percent nor more than 20 percent of the minimum weight of Portland cement required by table 552-1 may be replaced with fly ash at the above rate.

An air-entraining admixture shall be used to obtain the specified air entrainment.

Cement acceptance may be based on mill certification as well as from pretested and approved bins.

The cement and fly ash shall be well protected from rain and moisture, and any cement or fly ash damaged by moisture or which fails to meet any of the specified requirements shall be rejected and removed from the work. Cement stored by the contractor for a period longer than 60 days shall require the Engineer's approval before being used on the work. Cement of different brands, types, or from different mills shall be stored separately.

CONSTRUCTION

552.05 Performance

The contractor shall submit a written schedule of concreting operations, including personnel and equipment, when requested by the Engineer. The contractor shall give the Engineer 24-hour notice prior to placing any segment of the concrete work.

552.06 Batching

Measuring and batching of materials shall be done at a batching plant.

(a) Portland Cement. Either bagged or bulk cement may be used. No fraction of a bag of cement shall be used in a batch of concrete unless the cement is weighed.

All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be properly sealed and vented to preclude dusting during operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it.

Accuracy of batching shall be within 1 percent of the required weight.

(b) Water. Water shall be measured by volume or by weight. The device for the measurement of the water shall be readily adjustable and shall be capable of being set to deliver the required amount and to cut off the flow automatically when this amount has been discharged. Under all operating conditions, the device shall have an accuracy within 1 percent of the quantity of water required for the batch. The device shall be so arranged that the measurements will not be affected by variable pressures in the water supply line. Measuring tanks shall be of adequate capacity to furnish the maximum mixing water required and shall be equipped with outside taps and valves to provide for checking their calibration unless other means are provided for readily and accurately determining the amount of water in the tank. Wash water is not permitted to be used as a portion of the mixing water for succeeding batches.

(c) Aggregates. Stockpiles of aggregates shall be built up in layers of not more than 3 feet in thickness. Each layer shall be completely in place before beginning the next and shall not be allowed to side cast down over the previous layer. Aggregates from different sources and of different gradings shall not be stockpiled together.

Aggregates shall be handled from stockpiles or other sources to the batching plant in a manner that secures a uniform grading of material.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods and washed aggregates shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning if the car bodies permit free drainage. If the aggregates contain high or nonuniform moisture content, storage or stockpile periods in excess of 12 hours may be required.

Accuracy of aggregate batching shall be plus or minus 2 percent of each aggregate's required weight, and plus or minus 2 percent of the total required aggregate weight.

(d) Bins and Scales. The batching plant shall include separate bins for the bulk cements, for fine aggregate, and for each size of coarse aggregate; a weighing hopper; and scales capable of determining accurately the weight of each component of the batch.

Scales shall be accurate to 0.5 percent throughout the range of use. To ensure continued accuracy, the contractor shall have scales inspected, tested, sealed, and certified by a representative of the State agency responsible for weights and measures or a qualified manufacturer's representative, as often as necessary.

(e) Batching. When batches are hauled to a jobsite stationary mixer, cement shall be transported either in bags, or in bulk in a separate waterproof compartment. When bulk cement is transported in contact with aggregates, mixing shall commence within one-half hour of such contact.

Truck mixers may be used to haul unmixed concrete batches to the construction site only when cement is hauled separately in bags or waterproof compartments.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss.

(f) Admixtures. The contractor shall submit to the Engineer, for approval, a written procedure for adding the specified amount of admixture. He shall provide separate scales for the admixtures that are to be proportioned by weight and accurate measures for those to be proportioned by volume. All admixtures shall be measured into the mixer with an accuracy of plus or minus 3 percent.

Set retarding and/or water reducing admixture may be used provided they conform to the requirements of Type B or Type D of AASHTO M 194 or ASTM C 494. The type and quantity of the admixture to be used must be included in the mix design submitted to the Engineer. The use of the admixture shall conform to the manufacturer's recommendations.

When an air-entraining agent is being added at the mixer, the quantity or the strength of solution shall be varied as might be necessary to ensure full compliance with the requirements for air content of the concrete given in table 552-1.

The air-entraining agent may be introduced by means of an automatic dispensing device approved by the Engineer, or it may be introduced manually by pouring it on the aggregates in the skip of the mixer. When added manually, a quantity shall first be diluted with water, in the proportions specified, so that a volume of not less than 1 quart of the diluted solution is measured and added to each batch of concrete.

Admixtures, including fly ash, shall not be used to reduce the cement content below the minimum shown in the table 552-1. Admixtures containing chlorides as Cl in excess of 1 percent by weight shall not be used.

552.07
Mixing & Delivery

Concrete may be mixed at the site of construction, at a central point, by a combination of central point and truck mixing, or by a combination of central point mixing and truck agitating.

When concrete is delivered to the work site, a ticket showing dispatch time and mix design identification shall be supplied by the contractor.

Mixing and delivery of concrete shall be in accordance with the appropriate requirements of AASHTO M 157, Sections 8 and 9 with the following modifications:

(a) In addition to the requirement of Section 9.4 regarding number of truck mixer drum revolutions, the sum of all drum revolutions at both mixing and agitating speeds shall not exceed 300 before all concrete has been discharged from the drum, except that the sum of all drum revolutions shall not exceed 200 if the outside air temperature is over 85 °F. If mixing is done before arrival of the truck at the point of delivery, the drum shall again be rotated at mixing speed for 10 to 15 revolutions to reblend possible stagnant spots.

(b) If set retarding admixture is used, the sum of all drum revolutions at both mixing and agitating speeds shall not exceed 550 before all concrete has been discharged from the drum, except that the sum of all drum revolutions shall not exceed 450 if the outside air temperature is over 85 °F. In addition, the time limits specified in Subsection 9.6 may be extended up to an additional 2 hours by the Engineer.

(c) The last sentence of Subsection 9.6.1 is deleted.

(d) Subsection 9.9 is replaced by the following:

(1) Concrete delivered in outdoor temperatures of 35 °F or below shall meet the requirements of Subsection 552.08 of this specification.

(2) At the time of placement, concrete temperature shall be as specified in Subsection 552.08.

(e) Delivery of concrete shall be so regulated that placing is at a continuous rate unless delayed by the placing operations. The intervals between delivery of batches shall not be so great as to allow the concrete in place to harden partially, and in no case shall such an interval exceed 30 minutes.

(f) The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand, and water to coat the inside of the drum without reducing the required mortar content of the mix.

(g) Handmixing shall not be permitted, except in case of emergency and with written approval from the Engineer. When permitted, it shall be performed only on watertight platforms. Handmixed batches shall not exceed 1/12 cubic yard volume. Handmixing shall not be permitted for concrete that is to be placed under water.

(h) Mixers and agitators shall meet the requirements of Subsections 8.1 and 8.1.1, except 8.1.1 is modified to allow the use of mechanically operated counters, and 8.1.3 is deleted.

(i) Truck-mixed concrete shall have the cement transported separately from the aggregate and water. Cement shall be added to the mixer at the project site.

For batch mixing at the site of construction or at a central point, a batch mixer of an approved type shall be used. No mixer having a rated capacity of less than a one-bag batch shall be used. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity as shown on the manufacturer's standard rating plate on the mixer. The batch shall be so charged into the drum that a portion of the water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. Mixing time shall be measured from the time all materials, except water, are in the drum. Mixing time shall be not less than 60 seconds for mixers having a capacity of 2 cubic yards or less. For mixers having a capacity greater than 2 cubic yards, the mixing time shall be not less than 90 seconds. If timing starts the instant the skip reaches its maximum raised position, 4 seconds shall be added to the specified mixing time. Mixing time ends when the discharge chute opens.

The mixer shall be operated at the drum speed shown on the manufacturer's name plate on the mixer. Any concrete mixed less than the specified time shall be discarded and disposed of by the contractor without compensation.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the contractor will be permitted to continue operations while it is being repaired, provided an approved timepiece equipped with minute and second hands is furnished. If the timing device is not repaired within 24 hours, further use of the mixer will be prohibited until repairs are made.

552.08
Adverse Weather
Concrete

(a) Cold Weather. The contractor shall furnish the Engineer with a detailed plan of equipment and material to be used for protection of the concrete during the curing period.

When the air temperature is 35 °F or less at the time of mixing or placing, or an air temperature of 35 °F or less can be expected in the 24-hour period immediately following the concrete placing, the mixing water or aggregates, or both, shall be heated. The temperature of water and aggregate, and the resulting batch of mixed concrete shall be within the temperature ranges specified below.

Aggregates that contain frozen lumps shall not be used. If either the aggregates or water is heated to a temperature in excess of 100 °F, the water and aggregates shall be premixed so that the resulting temperature of the combined water and aggregates is not in excess of 100 °F when the cement is added to the batch.

Heating equipment or methods that cause uneven heating or alter or prevent the entrainment of the required amount of air in the concrete shall not be used. Aggregates may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire.

When aggregates are heated in bins, steam-coil or water-coil heating or other methods that will not be detrimental to the aggregates may be used. The use of live steam on or through binned aggregates shall not be permitted.

Heating of the cement or the adding of salt or other chemicals to the mix to prevent freezing will not be permitted.

Forms and reinforcement shall be free of ice, snow, and frost at the time of concrete placement. When the atmospheric temperature is below 40 °F the interior surfaces of forms, all reinforcement, and the surface of the concrete adjacent to the pour shall be preheated to 40 °F or higher.

When placed in the forms, the mixed concrete shall have a temperature of not less than 50 °F nor more than 80 °F for concrete in deck slabs, girders, and sections less than 24 inches thick; and not less than 50 °F nor more than 90 °F for concrete in sections 24 inches or more in thickness. Where insulated forms are used for protecting the concrete, the allowable temperature range of all concrete placed shall be from 50 °F to 90 °F.

When the air temperature is 35 °F or less, or when an air temperature of 35 °F or less can be expected within a period of 6 days following placing of the concrete, the work shall be protected by insulated forms or blankets or heated housing.

(1) Insulated Forms and Blankets. The contractor may protect structural concrete by the use of insulated forms or blankets as hereafter described.

When housing of the structure or section thereof can be delayed, but is subsequently required in accordance with the specifications, the contractor may protect structural concrete in bridge decks or similar sections with insulating blankets instead of housing, heating, and curing for the remainder of the protection period. The curing method shall prevent moisture loss on all exposed surfaces protected by insulating blankets.

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Insulation shall consist of bats or blankets of fiberglass, rock wool, balsam wool, insulation boards, or other approved material. Insulation used on placements having a thickness of 24 inches or less shall have an insulation value of not less than 7.0, and insulation used on placements having a thickness greater than 24 inches shall have an insulation value of not less than 5.0, based on the following formula:

$$R = \frac{T}{K}$$

where

R = *Insulation value*
T = *Thickness in inches*
K = *Thermal conductivity in Btus per hour per square foot for a temperature gradient of 1 °F per inch of thickness.*

Upon the Engineer's request, the contractor shall furnish the K value, as determined by the manufacturer, for the type of insulation proposed for use in protecting the work.

The bats or blankets shall be completely encased in suitable wind- and water-resistant covers that shall be fastened securely to wood forms between the studs and wales, with edges and ends sealed to the framing to minimize heat loss. The insulation shall be attached to steel forms by adhesive or other approved methods. Ribs and flanges of steel forms shall be covered by the insulating blankets, or separate strips of insulation shall be applied to them. The edges and corners of concrete shall be well insulated. Horizontal surfaces of concrete shall be protected by a layer of the insulating material securely fastened in place. The tops of placements, such as bridge decks and similar flat slab sections, shall be protected by tarpaulins over the insulation. Large insulating blankets may be wrapped around and securely fastened in place for curing concrete columns cast in prefabricated forms and similar concrete items. All joints in the blankets shall be sealed with tape.

Any tears in the cover shall be repaired. Where tie rods extend through the insulated form, a suitable washer shall be placed over the hole outside of the insulation and fastened to the form.

When insulating blankets are applied directly to concrete masonry, the methods of applying and securing the insulation shall be approved in advance by the Engineer. All joints shall be sealed.

The insulated forms or blankets shall remain in place for a protection period of at least 6 days (4 days when Type III cement is used) after placement of the concrete.

The contractor shall provide approved facilities and shall measure the temperatures inside and outside of the insulation and within the mass of the concrete at various locations in the unit. Frequent thermometer readings shall be taken and recorded and shall be available to the Engineer at all times. Approved recording thermometers may be used to obtain temperature records. Forms or insulation shall be loosened as required to control the temperature of the concrete. The temperature of the concrete shall not be allowed to exceed 120 °F nor fall below 45 °F during the protection period. In addition, the temperature at the surface of the concrete shall not be allowed to exceed 90 °F.

At the close of the protection period, the temperature of the concrete shall be gradually decreased to the temperature of the outside air at a rate not to exceed 40 °F per 24-hour period or 5 °F in any hour by loosening the forms or blankets.

Electric heating blankets and other suitable materials may be used instead of insulated blankets or bats when specifically approved by the Engineer for each application.

The contractor shall assume entire responsibility for the proper protection and final satisfactory condition of all concrete placed during cold weather or exposed to cold weather within the required protection period. This responsibility shall extend to the adequacy of all equipment and methods necessary to conform to the requirements of the contract. Any concrete that has been frozen or damaged by other causes shall, upon order of the Engineer, be removed and replaced with satisfactory concrete at the contractor's expense.

(2) Housing, Heating, and Curing. If the concrete temperatures cannot be maintained within the limits specified above by insulated forms or blankets, adequate housing shall enclose each section of a structure before placing the concrete in such section, except as follows:

a. The contractor may delay the erection of such housing if the air temperature is not expected to fall to 35 °F or below during the 24 hours immediately following placement of the concrete. Housing may be delayed until the temperature is expected to fall to 35 °F or below during any 24 hours of the succeeding 5-day period, provided that an adequate supply of housing material is maintained at the site and sufficient men and equipment are available to ensure the erection of suitable housing before the temperature falls to 35 °F.

b. The protective housing shall be of sufficient size to allow all concrete placing and finishing operations for any one placement to proceed under cover without hindrance. However, to facilitate the placement of concrete, the covering material may be installed immediately following the depositing of the concrete. The housing shall be constructed weather-tight in a manner that will ensure that specified temperatures will be maintained uniformly throughout the enclosure during the protection period.

c. Before starting concreting operations, the contractor shall have available ample and suitable equipment, for heating, curing, and protecting the concrete during the protection period. Heating may be by steam or hot air. A humid condition must be maintained within the housing during the heating period. Stoves or open-burning salamanders will not be permitted within the housing.

d. Application of heat that will endanger forms, falsework, or any part of the structure, or that will subject the concrete to drying out or other injury due to excessive temperatures, will not be permitted. The concrete surface shall be heated to maintain a temperature between 50 °F and 90 °F.

e. When housing is required prior to placement of concrete, heat shall be admitted to the housing sufficiently in advance of placing the concrete to ensure that the temperature of the forms and reinforcing steel will not be less than 40 °F. Within the enclosure or housing, a temperature not less than 45 °F nor more than 70 °F shall be maintained during placing of the concrete and for a protection period of at least 6 days thereafter or for the remaining number of days of such 6-day period that housing is required. The temperature within the enclosure shall be reasonably uniform throughout.

f. The contractor shall provide adequate fire protection when heating is in progress and shall maintain watchmen or other attendants to keep heating units in continuous operation.

g. The contractor shall provide reliable thermometers and take temperature readings within the enclosure at such points and at such times as are necessary to show the true temperature conditions to which the concrete is subjected. Outside air temperature recordings shall be made at the time of making the recordings within the enclosure. A copy of the temperature records shall be available to the Engineer at all times. Approved recording thermometers may be used to obtain all temperature records at the contractor's option.

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h. At the close of the heating period, the temperature within the enclosure shall be reduced in a manner that will avoid a sudden temperature change to the new concrete. The average rate of decrease shall not exceed 40 °F per 24-hour period until the outside air temperature is reached. The surface of the concrete shall be permitted to dry while temperatures are being equalized.

i. When pozzolan or fly ash cement is used, the required period of controlled temperature and moisture shall be:

Percentage of Cement Replaced by Weight	Required Period of Controlled Temperature and Moisture
10%	9 days
10-15%	10 days
16-20%	11 days

The above requirement for an extended period of controlled temperature and/or moisture may be waived if a compressive strength of 65 percent of the specified 28-day strength is achieved in 6 days.

(b) Hot Weather. Immediately prior to being placed, the temperature of plastic concrete shall not exceed 90 °F, except that bridge superstructure concrete shall not exceed 80 °F. Chipped or crushed ice may be used in the mix as a portion of the mixing water on a pound-for-pound basis. If ice is used, all ice shall be entirely melted at the completion of the mixing period.

When placing concrete deck slabs, if the air temperature near the slab's surface is expected to rise above 80 °F, the contractor shall schedule his operations so that finishing of the top of the slab is completed before this occurs or use hot weather concreting practices to maintain the slab surface temperature 80 °F or less until finishing is completed. An evaporation rate in excess of 0.1 pound per square foot per hour (as determined by Portland Cement Association Bulletin "Design and Control of Concrete Mixtures," current edition) will be considered cause for requiring the use of a protective housing when making bridge deck placements.

The protective housing shall be covered by waterproof material and shall be of sufficient size to allow the concrete placing and finishing operations for any one pour to proceed under the housing without hindrance until final set. However, to facilitate the placement of concrete, the covering material may be installed immediately following the depositing of the concrete and shall remain in place for a period of 12 hours following the completion of the deck pour or until the adverse weather has passed, whichever is less.

Fogging equipment shall be capable of applying water to the concrete in the form of a fine mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the deck. Fogging nozzles and water supply methods shall be approved by the Engineer in advance. Nozzles shall produce a true mist that will not harm the surface finish of fresh concrete. The mist shall be applied at the times and in the manner approved by the Engineer.

When pozzolan or fly ash modified cement is used, the required period of controlled moisture shall be as shown above in 552.08 (a)(2)i.

552.09 Consistency

Slump will be measured in accordance with AASHTO T 119 and shall meet the requirements shown in table 552-1.

552.10 Foundations, Falsework, & Forms

Preparation of foundations shall meet the requirements in Section 206. The elevations of the bottoms of footings as SHOWN ON THE DRAWINGS are approximate, and changes in dimensions or elevations of footings may be ordered by the Engineer.

Two weeks prior to placement of the concrete supported by falsework, three copies of detailed drawings of the falsework and/or formwork for cast-in-place concrete decks and superstructure shall be submitted to the Engineer for approval.

Falsework shall be built on foundations of sufficient strength to carry the loads, without appreciable settlement. Falsework that cannot be founded on solid footings must be supported by ample falsework piling. Forms for cast-in-place concrete bridge decks supported on girders shall be completely supported by the girders upon which the deck is to be cast; shoring to the ground or substructures is not permitted.

Falsework shall be built on foundations of sufficient strength to carry the loads with a deflection not to exceed 1/500 of the falsework span and shall be set to give the finished structure the lines and grades SHOWN ON THE DRAWINGS. Suitable screw jacks or wedges shall be incorporated into the falsework and adjusted to take up any settlement in the formwork either before or during the placing of concrete. An arch centering shall be so constructed as to permit its being lowered gradually and uniformly.

Forms shall meet the requirements below:

(a) General. Forms shall be rigid enough to prevent distortion and deflection due to the pressure of the concrete and other loads including vibration, incident to the construction operations. Forms shall be so constructed and maintained as to prevent the opening of joints due to shrinkage of the lumber. Deflection of forms shall not exceed 1/360 of the span under full load.

Forms for concrete containing a retarding admixture, fly ash, or other pozzolan replacement for cement, shall be designed to contain the lateral pressure exerted by the full anticipated height of fluidized concrete, unless documented information on initial set is provided by the manufacturer.

(b) Forms. Forms for all exposed concrete surfaces shall be one of the following:

(1) Faced with exterior-type plywood with the face grain running perpendicular to the supports.

(2) Lumber dressed at least on one side and two edges.

(3) Metal.

(4) Fiberglass.

In all cases, forms shall be so constructed as to produce mortar-tight joints and smooth, even concrete surfaces. Forms shall be filleted and chamfered 3/4 inch or as SHOWN ON THE DRAWINGS, and they shall be given a bevel or draft in the case of all projections, such as girders and copings, to ensure easy removal.

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Form sheets shall not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 inch at each end. Form supports shall be placed in direct contact with the flange of stringer or floor beam. All attachments shall be made by permissible welds, bolts, clips, or other means approved by the Engineer. However, welding of form supports to flanges of steel not considered weldable and to portions of flange subject to tensile stresses shall not be permitted. Welding and welds shall be in accordance with the provisions of AWS D1.1, Structural Welding Code, pertaining to fillet welds, except that 1/8 inch fillet welds will be permitted.

(c) Metal Ties. Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 1 inch from the face without injury to the concrete. In case wire ties are permitted, suitable cones shall be provided. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color.

(d) Walls. Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so extraneous material may be removed from the forms immediately before placing the concrete.

(e) Surface Treatment. All forms shall be treated with form-release agent prior to placing reinforcement; and, in addition, woodforms shall be moistened with water immediately before placing concrete. No material or treatment that will be detrimental to, adhere to, or discolor concrete shall be used.

(f) Metal Forms. The specifications for forms, including design, mortar-tightness, filleted corners, beveled projections, bracing, alinement, removal, reuse, and oiling, apply to metal forms.

(g) Permanent Steel Bridge Deck Forms. Permanent or stay-in-place metal forms will not be permitted under deck slabs unless SHOWN ON THE DRAWINGS.

All forms shall be installed in accordance with approved fabrication and erection drawings.

Form support provisions in Subsection 552.10(b) shall apply to permanent steel deck forms.

Where the galvanized coating of any permanently exposed form metal has been damaged, it shall be thoroughly cleaned, wire brushed, and painted with two coats of zinc oxide-zinc dust primer (Fed. Spec.-TT-P-641 Type II, no color added). Minor heat discoloration in areas of welds need not be touched up.

Transverse construction joints shall be located at the bottom of a flute and 1/4-inch weep holes shall be field drilled at approximately 12 inches on center along the line of the joint.

552.11
Placing Concrete

(a) General. Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer. The forms shall be cleaned of all debris before concrete is placed. The method and sequence of placing concrete shall be as approved by the Engineer.

Concrete shall be placed and consolidated by methods that will not cause segregation of the aggregates and will result in a dense homogeneous concrete that is free of voids and rock pockets. All concrete shall be used while fresh and before it has taken an initial set. Retempering any partially hardened concrete shall not be permitted. No pumping lines, pipes, chutes, conveyors, etc., containing aluminum, which may be in contact with the mixed concrete, shall be permitted.

Surfaces on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

Mixed concrete, after being deposited, shall be consolidated until all voids are filled and free mortar appears on the surface.

Placing of concrete for roadway deck shall be commenced at a time that will permit all required finishing operations to be conducted during daylight hours; however, upon prior written approval of the Engineer, night finishing operations may be performed under artificial illumination of suitable character, distribution, and intensity.

(b) Chutes and Troughs. Concrete shall be so placed as to avoid segregation of the materials and the displacement of the reinforcement.

Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.

All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. The water used for flushing shall be discharged clear of the concrete already in place.

Concrete shall not be dropped into the forms a distance of more than 5 feet, unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

In thin sections where there is not sufficient space inside the form to place by chute, concrete shall be placed through form windows, or the Engineer may permit dropping more than 5 feet, provided that the placing is so controlled by short chutes, baffles, or other means that the concrete will be placed without segregation, and mortar splatter on reinforcing steel will be minimized.

(c) Pneumatic Placing. The equipment shall be so arranged that no vibrations result that might damage freshly placed concrete. Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 10 feet from the point of deposit. The discharge lines shall be horizontal or incline upwards from the machine.

(d) Pumping. The equipment shall be so arranged that no vibrations result that might damage freshly placed concrete. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall produce a continuous stream of concrete without air pockets. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected so that there will be no contamination of the concrete or separation of the ingredients.

(e) Vibrating. All concrete, except seal concrete, shall be consolidated with approved mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to ensure proper and adequate compaction.

Vibrators shall be capable of transmitting vibration to the concrete at frequencies of not less than 7,000 impulses per minute and visibly affecting a properly designed mixture with 1-inch slump for a distance of at least 8 inches from the vibrator.

Vibrators shall be manipulated to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms. The concrete shall be placed as nearly as possible in its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted. The vibration at any point shall be of sufficient duration to accomplish consolidation, but shall not be prolonged to the point where segregation occurs.

The contractor shall have a back-up vibrator at the site of the work.

(f) Depositing Concrete Under Water. Concrete shall be deposited under water only in the presence of the Engineer and by the method described in the following paragraphs:

Only seal concrete shall be deposited under water. The concrete shall be placed carefully in a compact mass in its final position by means of a tremie or by other approved means, and the concrete shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces.

Concrete seals shall be placed in one continuous operation.

When a tremie is used, it shall consist of a steel tube not less than 10 inches in diameter constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be designed to permit free movement of the discharge end over the entire top of the concrete and to permit its being lowered rapidly when necessary to choke off or retard the flow. The tremie shall be filled by a method that will prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times.

The tremie tube shall be kept full to the top. When placing concrete through a tremie, two distinct handling devices shall be used; one to raise, lower, and place the tremie; the other to deliver concrete to the tremie. When a batch is dumped into the hopper at the top, the tremie shall be raised slightly, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper at the top of the tremie tube. The flow shall then be stopped by lowering the tremie.

When concrete is placed under water by pumping, the pump pipe shall be equipped with a bottom valve or other approved device to prevent mixing of water with the concrete in the pipe. The pump pipe shall be withdrawn as the concrete rises but the end shall, at all times, be below the surface of the concrete.

(g) Concrete Columns. Concrete in columns shall be placed in one continuous operation unless otherwise permitted by the Engineer. The concrete shall be allowed to set at least 12 hours before caps are placed, unless otherwise SHOWN ON THE DRAWINGS.

(h) Concrete Slab and Girder Spans. Slabs and girders having lengths of 30 feet or less shall be placed in one continuous operation.

Girders spanning more than 30 feet may be placed in two operations, the first operation being the placement of the girder stems to the bottom of the slab haunches. Adequate shear resistance shall be obtained by using a broom finish with 1/4-inch grooves on the surface of the first concrete pour.

The period between the first or girder placement and the second or slab placement shall be at least 24 hours. Immediately before the second placement, the contractor shall check all falsework for shrinkage and settlement and shall tighten all wedges to ensure minimum deflection of the stems due to the added weight of the slab.

The undersurface of cantilever brackets and overhanging slabs shall be provided with a drip groove, 1/2 inch in depth at a point not more than 6 inches from the outside face, to arrest the flow of moisture.

(i) Arches. Arch centering shall be constructed in accordance with construction drawings approved by the Engineer. Centering shall be lowered gradually and symmetrically to avoid overstresses in the arch.

Centering shall be placed upon approved jacks to provide means of correcting any slight settlement that may occur after concrete placement has begun. Any adjustments made necessary by settlement shall be made before the concrete has taken its initial set.

Railings and copings shall not be constructed until centering has been struck and the arch made self-supporting.

For closed-spandrel arches, portions of the spandrel walls necessary to avoid jamming of the expansion joints shall be left for construction subsequent to the striking of centers.

For filled-spandrel arches, the filling shall be placed as provided in Section 206, care being taken to load the ring uniformly and symmetrically. The filling material shall be acceptable to the Engineer and shall be placed in horizontal layers, carefully tamped, and brought up simultaneously from both haunches.

Wedge-shaped sections of filling material against spandrels, wings, or abutments will not be permitted.

(j) Concrete Railings, Parapets, and Curbs. Special care shall be exercised to obtain smooth, tight-fitting forms that can be held rigidly to line and grade and can be removed without injury to the concrete. All moldings, panel work, and bevel strips shall be constructed as SHOWN ON THE DRAWINGS, with neatly mitered joints. All corners in the finished work shall be true, sharp, clean-cut, and shall be free from cracks, spalls, or other defects.

Precast railing members shall be cast in mortar-tight forms. The precast members shall be removed from the molds as soon as the concrete is sufficiently hard and shall then be kept covered with water-saturated burlap or a tarpaulin for at least 3 days. After this treatment, the curing shall be completed by immersion in water or by spraying not less than twice a day for a period of not less than 7 days.

The method of storage and handling shall preserve the edges and corners true and even. Any precast members that become chipped, marred, or cracked before or during the process of placing shall be rejected and removed from the work.

In the construction of cast-in-place railing caps and copings built in connection with precast balusters, the balusters shall be protected from staining and disfigurement during the process of placing and finishing the concrete.

(k) Construction Joints. Construction joints shall be located where SHOWN ON THE DRAWINGS. Additional construction joints shall require written approval by the Engineer.

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At all construction joints, gauge strips 1-1/2 inches thick shall be placed inside the forms along all exposed faces to give the joints straight lines. Before placing fresh concrete, the surfaces of construction joints shall be sandblasted or washed and scrubbed with a wire broom, drenched with water until saturated, and kept saturated until the new concrete is placed.

Immediately prior to placing new concrete, the forms shall be drawn tight against the concrete already in place and the old surface shall be coated thoroughly with a very thin coating of neat cement mortar. Concrete in substructures shall be placed so that all horizontal construction joints will be truly horizontal and, if possible, in locations so that they will not be exposed to view in the finished structure. Where vertical construction joints are necessary, reinforcing bars shall extend across the joint to make the structure monolithic.

Dowels, load-transfer devices, and bonding devices shall be placed as SHOWN ON THE DRAWINGS.

(l) Expansion Joints. Expansion joints shall be located and formed as SHOWN ON THE DRAWINGS.

(1) Open Joints. Open joints shall be constructed by insertion and subsequent removal of a wooden strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete.

(2) Filled Joints. Poured expansion joints shall be constructed similarly to open joints.

When premolded expansion joints are specified, the thickness of the filler installed shall be as SHOWN ON THE DRAWINGS. The joint filler shall be cut to the same shape and size as that of the surfaces being joined. It shall be fixed firmly against the surface of the concrete already in place so that it will not be displaced when concrete is deposited against it. Where it is necessary to use more than one piece of filler to cover any surface, the abutting pieces shall be placed in close contact, and the joint between them shall be covered with a layer of asphalt-saturated roofing felt of not less than 40-pound grade, one side of which shall be covered with hot asphalt to ensure proper retention. Immediately after the forms are removed, the expansion joints shall be inspected carefully. Any concrete or mortar that has sealed across the joint shall be cut neatly and removed. When, during construction, an opening of 1/8 inch or more appears in any joint over which any traffic will occur, the opening shall be completely filled with asphalt.

Dowels, load-transfer devices, and other devices shall be placed as SHOWN ON THE DRAWINGS.

(3) Steel Joints. The plates, angles, or other structural shapes shall be accurately shaped at the shop to conform to the section of the concrete floor. Care shall be taken to ensure that the surface in the finished plane is true and free of warping. Positive methods shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be adjusted to compensate for the actual temperature of the structure at the time of concrete placement, and care shall be taken to avoid impairment of the clearance in any manner.

(4) Water Stops. Water stops shall be placed in accordance with Section 616.

(5) Compression Joint Seals. Compression joint seals shall be in one piece for the full length of transverse joints and in the longest practicable lengths for longitudinal joints. Joints shall be clean and dry and shall be made free of spalls and irregularities that would impair a tight seal in service. Seals shall be placed in the joint under compression, as recommended by the manufacturer, using the lubricant-adhesive as a covering film applied to both sides of the seal just prior to its installation. The top edges of the seal shall be set below the adjacent surfaces of the concrete, as SHOWN ON THE DRAWINGS, and the seal shall contact the walls of the joint throughout its length. Longitudinal elongation of an installed seal by 5 percent or more of its original length will be cause for its removal and reinstallation.

All lubricant-adhesive that comes to the top of an installed seal shall be removed before it dries, and all seals that show twist, curl, nicks, or other malformations as installed, shall be removed and replaced by a new seal.

(6) Elastomeric Expansion Joint Seal. The joint shall be furnished and installed in accordance with the details SHOWN ON THE DRAWINGS and with the manufacturer's recommendations.

(m) Anchor Bolts. All necessary anchor bolts in piers, abutments, or pedestals shall be accurately set either in the concrete as it is being placed, in holes formed while the concrete is being placed, or in holes drilled after the concrete has set, unless a specific method is SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. If a bolt is to be set in the concrete as it is being placed, the bolt shall be placed in a section of standard black pipe at least 2 inches larger in diameter than the bolt and shall be anchored by passing it through a heavy steel washer at the bottom of the pipe. Holes may be formed by inserting oiled wooden plugs, metal pipe sleeves, or other devices approved by the Engineer, into the fresh concrete and withdrawing them after the concrete has partially set. Holes so formed shall be at least 4 inches in diameter. If drilled, holes shall be at least 1 inch larger in diameter than the bolts used. During freezing conditions, anchor bolt holes shall be protected from water accumulations at all times. Bolts shall be set accurately and fixed with grout completely filling the holes. A nonshrink grout approved by the Engineer shall be used.

Anchor bolts used in connection with expansion shoes, rollers, and rockers shall be located with due regard to the temperature at the time of erection. The nuts on anchor bolts at the expansion end of a span shall be adjusted to permit free movement of the span and then burred to prevent further tightening by vibration unless otherwise SHOWN ON THE DRAWINGS.

(n) Shoes and Bearing Plates. Preferably, bridge seat bearing areas shall be finished high and rubbed to grade. Shoes and bearing plates shall be set in accordance with Section 555.

(o) Drainage Holes and Weep Holes. Drainage holes and weep holes shall be constructed in the manner and at the locations SHOWN ON THE DRAWINGS. Ports or vents for equalizing hydrostatic pressure shall be placed below low water.

Forms for weep holes through concrete may be clay pipe, plastic pipe, concrete drain pipe, wooden boxes, or metal. If wooden forms are used, they shall be removed after the concrete is placed. Exposed surfaces of metal drains shall be coated or uncoated as SHOWN ON THE DRAWINGS.

(p) Pipes, Conduits, and Ducts. Pipes, conduits, and ducts that are to be encased in concrete shall be installed before the concrete is placed. Unless otherwise SHOWN ON THE DRAWINGS, pipes embedded in concrete shall be standard, lightweight galvanized steel or plastic pipes. Pipes shall be held or braced rigidly during concrete placement in order to prevent their displacement.

(q) Loads on New Concrete Structures. No load shall be placed upon new concrete structural elements until tests on concrete cylinders cast from the same concrete and cured under the same conditions as the structural element indicate that all concrete has attained a minimum of 80 percent of the specified 28-day design strength.

Traffic will not be permitted on concrete bridges until the concrete has attained the design strength SHOWN ON THE DRAWINGS.

In lieu of the above requirements, the minimum required time before a load may be placed on a new concrete structural element shall be 7 days after placement for concrete made with Type I or II cement or 3 days after placement for concrete made with Type III cement. However, when pozzolan or fly ash modified concrete is used, the placement of additional loads shall be based solely upon 80 percent of required 28-day compressive strength.

552.12
Removal of Forms
& Falsework

Forms and falsework shall not be removed without approval of the Engineer. The Engineer's approval shall not relieve the contractor of responsibility for safety and protection of the work. Blocks and bracing shall be removed at the time the forms are removed, and in no case shall any portion of the wood forms be left in the concrete.

Falsework removal for continuous or cantilevered structures shall be performed so that the structure is gradually subjected to its working stress.

When concrete strength tests are used for removal of forms and supports, removal should not begin until the concrete has attained the percentage of the specified 28-day compressive strength shown in Column 3 below.

When fly ash modified concrete is used, removal of forms shall be based solely upon criteria shown in Column 3 below.

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If field operations are not controlled by beam or cylinder tests, the forms and falsework for various parts of the structure shall not be removed before the number of days specified in Columns 1 and 2 of the following table have elapsed after the placing of the concrete, exclusive of days when the temperature is below 50 °F.

Forms and falsework shall not be released from under concrete that has been cured at a temperature continuously under 50 °F without first determining if the concrete has gained the specified strength, no matter how much time has passed.

Unless approved otherwise by the Engineer, substructure concrete shall reach the required 28-day compressive strength prior to erecting any superstructure or additional substructure elements.

	Column 1	Column 2	Column 3
Concrete Structure	Standard Concrete	Early Strength Concrete (Type III Cement)	Percent of Required 28-Day Comprehensive Strength
Columns and wall faces (not yet supporting loads)	3 days	2 days	50%
Mass piers and mass abutments (not yet supporting loads) except pier caps	3 days	N/A[b]	50%
Sidewalk on bridges; sidewalk forms shall, in all cases, be released before the main girder and slab forms are released[a]	10 days	4 days	70%
Box girders	14 days	7 days	80%
T-beam girders, slabs, crossbeams, caps, pier caps not continuously supported, struts, and top slabs on concrete box culverts[a]	14 days	7 days	80%
Trestle slabs, when supported on wood stringers[a]	10 days	4 days	70%
Slabs, when supported on steel stringers or prestressed concrete girders[a]	10 days	4 days	70%
Pier caps continuously supported[a]	7 days	3 days	60%
Arches[a]	21 days	10 days	95%
Rail bases, traffic railings, and median barriers	3 days	2 days	50%

[a] Items apply to falsework and forms supporting the full load of the concrete.
[b] Not applicable.

In continuous structures, falsework shall not be released in any span until the first and second adjoining spans on each side have reached the strength specified herein or in the SPECIAL PROJECT SPECIFICATIONS. When cast-in-place post-tensioned bridges are constructed, falsework shall remain in place until all post tensioning has been accomplished.

Falsework under all spans of continuous structures shall be completely released before concrete is placed in curbs, railings, and parapets.

In order to determine the condition of column concrete, forms shall be removed from columns before releasing supports from beneath beams and girders.

The forms for footings constructed within cofferdams or cribs may be left in place when their removal would endanger the safety of the cofferdam or crib, and when the form so left intact will not be exposed to view in the finished structure. All other forms shall be removed whether above or below the ground line or water level.

All removable forms shall be removed from the cells of concrete box girders unless otherwise SHOWN ON THE DRAWINGS or permitted by the Engineer. No forms shall be left that might jeopardize drainage or enclosed utilities.

To facilitate finishing, forms on exposed surfaces not supporting loads may be removed earlier than that specified above, when approved by the Engineer.

Falsework and centering for spandrel-filled arches shall not be struck until fills behind abutments have been placed up to the spring line. Falsework supporting the deck of rigid frame structures shall not be removed until fills have been placed behind the vertical legs.

552.13 Finishing Concrete Surfaces

Unless otherwise authorized, the formed surface of the concrete shall be finished immediately after form removal.

All formed concrete surfaces shall be given a Class 1 finish. If further finishing is required, exposed surfaces SHOWN ON THE DRAWINGS or DESIGNATED in the SPECIAL PROJECT SPECIFICATIONS shall be given a Class 2 finish. Other finish classes may be SHOWN ON THE DRAWINGS for DESIGNATED surfaces. All roadway and sidewalk surfaces shall be given a float finish in accordance with paragraph (c) below.

(a) Class 1, Ordinary Surface Finish. As soon as the forms are removed, all projecting wire or metal devices that have been used for holding the forms in place and that pass through the body of the concrete shall be removed or cut back at least 1 inch beneath the surface of the concrete. Lips of mortar and all irregularities caused by form joints shall be removed.

All small holes, depressions, and voids that show upon the removal of forms shall be filled with cement mortar mixed in the same proportions as that used in the body of the work. In patching larger holes and honeycombs, all coarse or broken materials shall be chipped away until a dense uniform surface of concrete exposing solid coarse aggregate is obtained. Feathered edges shall be cut away to form faces perpendicular to the surface. All surfaces of the cavity shall be saturated thoroughly with water, after which a thin layer of neat cement mortar shall be applied. The cavity shall then be filled with stiff mortar, composed of one part of Portland cement to two parts of sand, that shall be thoroughly tamped into place. The mortar shall be preshrunk by mixing it approximately 30 minutes before using. The length of time may be varied in accordance with the brand of cement used, temperature, humidity, and other local conditions. The surface of this mortar shall be floated with a wooden float before initial set takes place and shall be neat and workmanlike in appearance.

For patching large or deep areas, coarse aggregate shall be added to the patching material and special precautions shall be taken to ensure a dense, well-bonded, and properly cured patch.

Areas of honeycomb that exceed 2 percent of the surface area of a structural element may be considered sufficient cause for rejection of the structural element.

The mortar patches shall be cured in accordance with Subsection 552.14. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

All surfaces that cannot be repaired satisfactorily shall be rubbed as specified for a Class 2 finish.

(b) Class 2, Rubbed Finish. After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be thoroughly saturated with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the patch to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place.

After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

After the final rubbing is complete and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder, and objectionable marks.

(c) Float Finish.

(1) General. Immediately after the concrete has been struck off to the required grade, the horizontal surface shall be hand finished to smooth even surfaces by both longitudinal and transverse movement of wooden floats, or other suitable means.

After floating has been completed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 10-foot straightedge. The straightedge shall be held in contact with the surface in successive positions parallel to the slab centerline and the whole area gone over from one side of the slab to the other. Advancement along the slab shall be in successive stages of not more than one-half the length of the straightedge. Any depressions found shall be filled immediately with freshly mixed concrete, and any high areas shall be cut down. The surface shall be struck off, consolidated, and refinished. Special attention shall be given to ensure that the surface across joints fully meets the requirements for smoothness. The straightedge testing and refloating shall continue until the entire surface is found to be free from observable departures from the straightedge and the slab has the required grade and crown.

As soon as the concrete has hardened sufficiently, the surfaces shall be given a further test for trueness using a 10-foot straightedge or other specified device. Areas showing high spots of more than 1/8 inch shall be marked and immediately ground down with a diamond-faced, saw-type cutting machine, capable of cutting through mortar and aggregate without breaking or dislodging the aggregate or causing spalls, to an elevation where the area or spot will not show surface deviations in excess of 1/8 inch when tested with a 10-foot straightedge.

The 10-foot straightedge shall be provided by the contractor and the straightedge testing shall be performed by contractor personnel while the Engineer is present.

(2) Bridge Decks. On bridge decks, a smooth riding surface of uniform texture, true to the required grade and cross section, shall be obtained. The contractor shall use finishing machines meeting the requirements specified herein for finishing bridge roadway deck concrete. Hand-operated strike-off devices may be used for small areas or under special conditions when approved by the Engineer.

Finishing of concrete placed in bridge decks shall consist essentially of striking off the surface of the concrete as placed and floating the surface so struck off.

The placing of concrete in bridge decks will not be permitted unless the rate of producing and placing concrete will be sufficient to complete the proposed placing and finishing operations within the scheduled time, unless experienced finishing machine operators and concrete finishers are employed to finish the deck, and unless the fogging equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. Finishing machines shall be set up sufficiently in advance of use to permit inspection by the Engineer during the daylight hours before each placement.

The placing of concrete in bridge decks shall cease early enough to permit completion of finishing operations during daylight hours, unless night finishing operations have been approved in advance by the Engineer as specified in Subsection 552.05.

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Rails for the support and operation of finishing machines and headers for hand-operated strike-off devices shall be completely in place and firmly secured for the scheduled length for concrete placement before placing of concrete will be permitted. Rails for finishing machines shall extend sufficient distance beyond both ends of the scheduled length for concrete placement to permit the float of the finishing machine to fully clear the concrete to be placed, unless otherwise approved by the Engineer. Rails or headers shall be adjustable for elevation and shall be set to elevations, with allowance for anticipated settlement, camber, and deflection of falsework, as required to obtain a bridge deck true to the required grade and cross section. Rails or headers shall be of a type and shall be so installed that no springing or deflection will occur under the weight of the finishing equipment and shall be so located that finishing equipment can operate without interruption over the entire bridge deck being finished. Rails or headers shall be adjusted as necessary to correct any unanticipated settlement or deflection that may occur during finishing operations.

Immediately prior to placing bridge deck concrete, the contractor shall check all falsework and wedges and shall make all necessary adjustments. Care shall be exercised to ensure that settlement and deflection due to the added weight of the bridge deck concrete will be at a minimum. Suitable means, such as telltales, shall be provided by the contractor to readily permit measurement of settlement and deflection by the Engineer as it occurs.

Should settlement or other unanticipated events occur that would prevent obtaining a bridge deck meeting the requirements of this specification, placing of deck concrete shall be discontinued until corrective measures are provided. If satisfactory measures are not provided prior to initial set of the concrete in the affected area, the placing of concrete shall be discontinued and a bulkhead installed at a location approved by the Engineer. All concrete in place beyond the bulkhead shall be removed.

Concrete for bridge decks shall be placed in a uniform heading approximately normal to the structure centerline. The rate of placing concrete shall be limited to that which can be finished before the beginning of initial set, but in no case shall concrete be placed more than 8 feet ahead of the finishing machine.

All concrete bridge decks shall be placed continuously full length of the structure or superstructure unit unless otherwise SHOWN ON THE DRAWINGS or approved in writing by the Engineer. The contractor shall provide sufficient material, equipment, and manpower to complete a finished bridge deck at a minimum rate of 20 linear feet per hour unless otherwise SHOWN ON THE DRAWINGS.

Immediately after the concrete has been placed and consolidated, the surface shall be struck off with the finishing machine or hand-operated screed until the required surface is obtained. The use of "jitterbugs" or similar devices will not be permitted. The strike-off method and equipment shall be subject to approval by the Engineer. Approval shall be withdrawn if performance is not satisfactory. The equipment shall be capable of finishing roadway decks within the surface tolerances set forth in these specifications. Improper adjustment and operation that results in unsatisfactory consolidation and smoothness shall be corrected immediately. Unsatisfactory performance may be cause for rejection of the equipment and removal of the in-place concrete. Following the completion of the strike-off, the roadway slab surface shall be floated to a smooth, uniform surface by means of floats 10 feet or more in length. Adequate floats shall be used to remove roughness and minor irregularities left by the strike board or finishing machine and to seal the concrete surface. Excessive working of the concrete surface will not be permitted. All floats shall be used so that each transverse pass overlaps the previous pass by a distance equal to at least one-half the length of the float.

When hand-operated float boards are used, they shall be from 12 feet to 16 feet long, ribbed and trussed as necessary to provide a rigid float, and equipped with adjustable handles at each end. The float shall be wood not less than 1 inch thick and a minimum of 8 inches wide. Adjusting screws, spaced not to exceed 24 inches on centers, shall be provided between the float and the rib. The float board shall be maintained free of twist and true at all times.

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Hand-operated float boards shall be operated from transverse finishing bridges. The finishing bridges shall completely span the roadway area being floated, and a sufficient number of finishing bridges shall be provided to permit operation of the floats without undue delay. Not less than two transverse finishing bridges shall be provided when hand-operated float boards are used. When a finishing machine is used for longitudinal floating, one finishing bridge equivalent to the transverse finishing bridge specified herein shall be furnished for use by the Engineer.

All finishing bridges shall be of rigid construction, free of wobble and spring when used by the operators of longitudinal floats, and easily moved.

In advance of curing operations, the surface of the concrete shall be textured with metal tines to produce grooving 3/16 inch deep on 1/2-inch centers unless otherwise SHOWN ON THE DRAWINGS. The grooving shall be transverse unless otherwise SHOWN ON THE DRAWINGS. The operation shall produce a hardened surface having a uniform texture. Sidewalks and tops of curbs shall be given a fine broom or brush finish, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

(d) Special Finishes. Details for special finishes SHOWN ON THE DRAWINGS will be given in the SPECIAL PROJECT SPECIFICATIONS.

552.14
Curing of Concrete

(a) General. All newly placed concrete shall be cured, and curing shall begin immediately after finishing and continue for at least 7 days. For fly ash or pozzolan modified concrete, the curing period shall be as shown in Subsection 552.08(a)(2)i. Curing shall be done so that moisture is always present and shall be an integral part of the concreting operations. Improperly cured concrete will be considered defective and placing operations shall be suspended until proper procedures are put into effect.

If a formed surface is to be rubbed, the concrete shall be kept moist before and during the rubbing, and the curing shall be initiated immediately following the first rub, while the concrete surface is still moist.

When the air temperature is expected to fall below 35 °F, the contractor shall provide suitable measures to maintain the concrete surface temperature between 50 °F and 90 °F and comply with all other applicable provisions of Subsection 552.08. The contractor shall furnish recording thermometers with a range of 0 °F to 212 °F and a recording capability of at least 24 hours. If the structure is enclosed, combustion heaters shall not contact the concrete surface and shall be vented to the outside of the enclosure.

(b) Methods. Concrete shall be cured by any one method or combination of methods listed below, consistent with any limitations given within a particular method.

The top surface of bridge decks, approach slabs, sidewalks, and curbs shall be cured by the method of supplying additional moisture, by the curing compound method of preventing moisture loss, or by the method of water curing.

(1) Supplying Additional Moisture. This method shall include supplying additional moisture by ponding, sprinkling, or fogging. Coverings such as burlap shall be used to retain water. The use of sawdust will not be allowed, and coverings that cause unsightly discoloration of concrete shall not be used. Any method that results in the concrete being alternately wet and dry will be considered an improper curing procedure. Coverings shall be placed as soon as possible after finishing operations have been completed and there is no danger of surface damage. They shall be kept continuously moist. This method shall also be used for curing all construction joints.

Fogging equipment shall be approved by the Engineer in advance and shall be capable of applying water to the concrete in the form of a fine mist in sufficient quantity to curb the effects of rapid evaporation of mixing water from the concrete on the deck resulting from wind, high temperature, low humidity, or a combination of these factors.

(2) Preventing Moisture Loss. This method shall consist of preventing moisture loss from the concrete. It may be done with the use of approved waterproof paper, plastic sheets, or liquid-membrane curing compound, except where other requirements prohibit the use of these compounds. If a formed surface is to be rubbed, the concrete shall be kept moist before and during the rubbing, and the curing shall be initiated immediately following the rubbing while the concrete surface is still moist. Unless a curing compound is used, bridge decks, approach slabs, sidewalks, and curbs shall be covered with burlap or sand blankets as soon as the concrete is sufficiently set to support this material without damage to the finish. This moisture-retaining material shall then be saturated with water and the entire area covered with waterproof paper or plastic sheeting.

a. Waterproof Paper. The paper shall be the widest practicable width, and adjacent sheets shall overlap a minimum of 6 inches and shall be tightly sealed with pressure-sensitive tape, mastic, glue, or other methods approved by the Engineer to form a complete waterproof cover of the entire concrete surface. The paper shall be secured so wind will not displace it. Should any portion of the sheets be broken or damaged before expiration of the curing period, the broken or damaged portions shall be immediately repaired. Sections that have lost their waterproof qualities shall not be used.

b. Plastic Sheets. The sheets shall be used in the same manner as required above for waterproof paper. Care shall be taken not to exceed the maximum temperature requirements when nontransparent sheets are used.

c. Curing Compounds. Type 1-D or Type 2 liquid membrane curing compounds may be used as the initial and final curing agents on structural concrete subject to the following limitations:

1. If the membrane film is broken or damaged at any time during the curing period, the area or areas shall be recoated to the original requirements.

2. Curing compounds shall be applied to unformed areas as soon as the water sheen has practically disappeared from the finished concrete or as soon as the forms have been removed from surfaces not to be rubbed.

3. Areas receiving a rubbed finish shall be cured with Type 1-D curing compound only.

4. If there is any delay in applying curing compound, the surface shall be protected by supplying additional moisture until compound can be applied.

5. Curing compound shall be applied with equipment that will produce a fine spray, and all compounds shall be thoroughly agitated just prior to use. The surface shall be sprayed again immediately at right angles to the first application. The rate of each application shall be not less than 1 gallon for each 150 square feet of surface. Care shall be taken to prevent application to joints where concrete is required to be bonded to reinforcement steel and to joints where joint sealer is to be placed.

(3) Steam and Radiant Head Curing Methods. Steam and radiant heat curing methods may be used for Class P and precast concrete. The methods shall meet the requirements of Section 553.

(4) Water Curing. Concrete may be cured under water if the temperature of the water does not fall below 35 °F.

**552.15
Opening to Traffic**

No traffic shall be permitted on concrete bridge decks until:

(a) Curbs, bridge railing, guardrail, and object markers SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS are completely in place.

(b) The compressive strength of concrete in the deck reaches the specified 28-day strength, as determined by compressive strength tests on cylinders cured with the deck.

(c) In the absence of compressive tests specified in (b), no traffic shall be permitted on concrete bridge decks for at least 28 days after placement of all deck concrete, or longer if determined necessary by the Engineer.

Upon completion of placement of all bridge deck concrete, the contractor shall erect barricades at each end of the bridge if the road approaches have been constructed to the point the vehicles could drive onto the bridge deck. Barricades shall be located to physically prevent vehicular access to the bridge deck. Barricades shall not be removed until the bridge deck is open to traffic.

552.16
(Reserved)

MEASUREMENT

552.17
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

No deduction will be made for the volume occupied by pipes less than 8 inches in diameter nor for reinforcing steel, anchors, conduits, weep holes, piling, or chamfers less than 6 inches on a side. The volume of fillets less than 6 inches on a side and of varying thickness haunches between prefabricated girders and bridge decks shall not be included.

The quantity shall include Type III cement when used in place of Type I or II; furnishing mix designs and materials for testing; furnishing and placing joint fillers, sealers, and waterstops; and all formwork, falsework, finishing and curing, admixtures, and increased cement content.

Class A concrete placed where seal concrete was specified will be considered seal concrete.

PAYMENT

552.18
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
552(01)	Structural Concrete, Class ____	C.Y.
552(02)	Structural Concrete, Class ____, ________ . . .	C.Y.
552(03)	Structural Concrete, Class ____	L.S.
552(04)	Structural Concrete, Class ____, ________ . . .	L.S.
552(05)	Seal Concrete	C.Y.

The following percentages of the price will be allowed for progress payments as the work progresses:

Portion of Work Completed	Percent of Price
Formwork and Falsework in Place	50
Reinforcing Steel in Place	65
Concrete Placed, Finished, and Cured	90
Forms Removed and Cleanup Completed	100

Section 553 - Prestressed Concrete Structures

DESCRIPTION

553.01
Work

This work shall consist of the construction of prestressed concrete structures and the prestressed concrete portions of composite structures. The work shall include the furnishing and installing of any appurtenant items necessary for the particular prestressing system to be used, including grout. For cast-in-place prestressed concrete, the term "member" as used in this section shall be considered to mean the concrete that is to be prestressed.

It shall include the manufacture, transportation, and storage of beams, slabs, piling, and other structural members. It shall also include the installation of all precast prestressed members except piling, which shall be placed as provided for in Section 551. Prestressed members shall be furnished complete, including all concrete, prestressing steel, bar reinforcing steel, and incidentals in connection therewith.

553.02
Prestressing Methods

Unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS, only the pretensioning method of stressing will be allowed. The method of pretensioning will be optional with the contractor. subject to the requirements hereinafter specified.

Prior to casting any prestressed members, the contractor shall submit to the Engineer complete details of the method, materials, and equipment proposed for use in the prestressing operations. Such details shall outline the method and sequence of stressing, complete specifications and details of the prestressing steel and anchoring devices proposed for use, anchoring stresses, type of enclosures, and all other data pertaining to the prestressing operations, including the proposed arrangement of the prestressing units in the members, pressure grouting materials, and equipment.

553
.04

Shop drawings shall be required for all prestressed precast members. Four sets of all shop drawings or two sets plus one reproducible set of all shop drawings, including the concrete mix design for each class of concrete to be used, shall be submitted to the Engineer a minimum of 21 days in advance of planned construction. Mix designs shall have been reviewed and shop drawings shall have been approved by the Engineer and returned to the contractor prior to construction, including fabrication of prestressed members.

Shop drawings for prestressed members shall include the prestressing bed layout and overall length between grips at fixed and jacking ends, the type of equipment to be used, the specific prestressing method, and the strand tensioning sequence. They shall also include the strand pattern at midspan and at centerline of bearing; location of total strand center of gravity at midspan, at hold-down points, at quarter points, and at centerline of bearing; and lifting devices and threaded inserts (brand name and part number). These shop drawings shall be accompanied by the calibration curve for the gauge and jacking system, the prestressing strand certification, the stress-strain curve for the prestressed strands, and computations for strand geometry, pressure gauge readings, and strand elongation measurements.

553.03
Consulting Service

The contractor shall certify to the Engineer that a technician skilled in the approved prestressing method will be available to the contractor to give such aid and instruction in the use of the prestressing equipment and installation of materials as may be necessary to obtain required results.

MATERIALS

553.04
Requirements

Materials shall meet the requirements of the following Subsections:

Concrete	552.03-04
Grout and Mortar	701.02-03
Reinforcing Steel	709.01
Prestressing Steel	709.03
Structural Steel	717.01
Hardware, Nuts, and Bolts	717.02-03
Joint Fillers	705.01
Elastomeric Bearing Pads	717.13

The concrete shall be Class P unless otherwise SHOWN ON THE DRAWINGS. Concrete in prestressed members shall have a 28-day design compressive strength (f'c) as SHOWN ON THE DRAWINGS. The concrete mix shall be designed by the contractor in accordance with Subsection 552.02(b). Lightweight concrete will not be permitted unless otherwise SHOWN ON THE DRAWINGS.

All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times. Prestressing steel that has sustained physical damage other than that allowed by Subsection 553.10 shall be rejected.

Prestressing steel shall be packaged in containers or other shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete.

All wire shall be free from defects and shall have a smooth surface finish. Material that shows defects will be rejected.

553.05 Testing

All wire, strand, anchorage assemblies, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. All samples submitted shall be representative of the lot to be furnished and, in the case of wire or strand, shall be taken from the same master roll. All of the materials specified for testing shall be furnished free of cost and shall be delivered 30 days prior to the anticipated time of use.

If requested by the Engineer, the vendor shall furnish samples at least 7 feet long for each strand size. A sample shall be taken from each coil. The selection of samples will be made at the manufacturer's plant by the Engineer.

When prestressing systems have been previously tested and approved for similar projects by an agency acceptable to the Engineer, complete tendon samples need not be furnished, provided there is no change in the materials, design, or details previously approved.

The strength of precast concrete required prior to release of pretensioned strands or required prior to lowering of curing temperature of nonprestressed members shall be determined by tests on test cylinders cast and cured under conditions in which the time-temperature relationship of the cylinder will simulate as nearly as possible that obtained during the curing of the structural member. When the forms are heated by steam or hot air, the cylinder will be placed in the lowest heat zone during the curing period. When forms are heated by some other means, a recording of the time-temperature relationship of the test cylinder must be available for comparison with that of the prestressed unit.

The test cylinders shall be molded, cured, and tested in accordance with AASHTO T 126 and T 22 for 28-day test cylinders and AASHTO T 23 for test cylinders cured with the members. When accelerated curing methods are used, the cylinders shall be allowed to cool for at least 1/2 hour prior to capping and caps of sulfur compound shall be allowed to cure 1/2 hour before testing.

As a minimum, the following numbers of test cylinders shall be taken. More shall be taken if the Engineer judges it necessary.

Prestressed members (from the same placements):

Number of Members/Day	Release Test Cylinders Taken[a]	Minimum Cylinders Broken (Release Test)	28-Day Strength Test Cylinders Taken and Broken[a]
1	3	2	3
2	3	1 per beam	4[b]
3	3[c]	1 per beam	6[b]
4	4[c]	1 per beam	8[b]
5	5[c]	1 per beam	10[b]
6	6[c]	1 per beam	12[b]
7	7[c]	1 per beam	14[b]
8	8[c]	1 per beam	16[b]

[a] Assumes all concrete is air-entrained or non-air-entrained. If both types of concrete are used in the same member, the number of test cylinders listed shall be taken from the air-entrained concrete and the same number of test cylinders shall be taken from the non-air-entrained concrete.

[b] Two test cylinders taken from each member.

[c] One test cylinder taken from each member.

CONSTRUCTION

553.06
Performance

Prestressed concrete structural members shall be constructed in accordance with Section 552, and reinforcing steel shall be placed in accordance with Section 554.

The Engineer shall be notified a minimum of 7 days prior to fabrication of any prestressed members so that inspection of fabrication operations can be arranged. Dimensional tolerances for prestressed girders shall be as given in Division 5, Section 5 of PCI Manual 116-77 ("Manual for Quality Control: Precast Prestressed Concrete Products," Prestressed Concrete Institute, Chicago, Illinois).

553.07
Prestressing Equipment

Hydraulic jacks used to stress tendons shall be equipped with either a pressure gauge or a load cell for determining the jacking stress. The pressure gauge, if used, shall have an accurate reading dial at least 6 inches in diameter and each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force, and shall be accompanied by a certified calibration chart. The load cell, if used, shall be calibrated and shall be provided with an indicator by which the prestressing force in the tendon can be determined. The range of the load cell shall ensure that the lower 10 percent of the manufacturer's rated capacity will not be used in determining the jacking stress.

Safety measures shall be taken by the contractor to prevent accidents due to possible breaking of the prestressing steel or the slipping of the grips during the prestressing process.

553.08
Casting Yard

Prestressed concrete members shall be manufactured in commercial precasting yards unless otherwise approved in writing by the Engineer.

553.09
Placing Steel

All steel units shall be accurately placed in the position SHOWN ON THE DRAWINGS and in accordance with Section 554.

Threaded inserts shall develop the full tensile strength of bars or bolts they secure. Unless otherwise SHOWN ON THE DRAWINGS, lifting devices of adequate strength to safely lift the girders shall be provided within 2 feet of the girder ends.

No welds or grounds for welding equipment shall be made on the forms or on the steel in the member after the prestressing steel has been installed.

Wires, wire groups, parallel-lay cables, and any other prestressing elements shall be straightened to ensure proper position in the enclosures. Suitable horizontal and vertical spacers shall be provided, if required, to hold the wires in position.

553.10 Stressing

The prestressing element shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongations produced. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete nor end anchorages released until the concrete has attained a compressive strength, as shown by cylinder tests, of at least 4,000 psi unless otherwise SHOWN ON THE DRAWINGS. The elements shall be cut or released in such an order that lateral eccentricity of prestress will be at minimum.

Strands should be stressed when the Engineer is present. The contractor or his representative shall record the pretensioning gauge pressures and measured strand elongations and provide a copy to the Engineer.

A seven-wire strand, with one broken wire, may remain in the member, provided it is within the following limits established for the member:

For members with:

Less than 20 strands, no wire breaks permitted.
20 to 39 strands, 1 wire break permitted.
40 to 59 strands, 2 wire breaks permitted.
60 or more strands, 3 wire breaks permitted.

The occurrence of more than the permissible number of wire breaks or more than one broken wire in any individual strand shall require that the strand or strands be removed and replaced. Any wire breaks that are permitted to remain in the member shall be located and the broken ends shall be securely wrapped with tie wire to prevent ravelling.

553.11 Placing Concrete

Concrete should not be deposited in the forms until the Engineer has inspected the placing of the reinforcement, enclosures, anchorages, and prestressing steel. The concrete shall be vibrated in such a way to avoid displacement of reinforcement, conduits, or wires.

Prior to placing concrete, the contractor shall ensure that all ducts are unobstructed.

553.12 Curing

Steam curing or radiant heat with moisture process may be used as an alternative to water curing. The casting bed for any unit cured with steam shall be completely enclosed by a suitable type of housing, tightly constructed to prevent the escape of steam and exclude outside atmosphere. Two to 4 hours after the placement of concrete and after the concrete has undergone initial set, the first application of steam shall be made, unless retarders are used, in which case the waiting period before application of the steam shall be increased to 4 to 6 hours.

For accelerated curing, a minimum of one continuous temperature recording device shall be used per 100 feet of continuous bed length being used. Copies of the temperature records, with the identification of the girder, shall be furnished to the Engineer.

Curbs and diaphragms cast after the prestress member has been cured or separately placed may be steam cured for a minimum of 12 hours at 100 °F to 160 °F or moist cured for a minimum of 3 days in accordance with Subsection 552.14.

The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 40 °F per hour until a maximum temperature of from 140 °F to 160 °F is reached. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 40 °F per hour until a temperature has been reached of 20 °F above the temperature of the air to which the concrete will be exposed. The concrete shall not be exposed to temperatures below freezing until the specified 28-day strength has been achieved.

Radiant heat shall be applied to beds by means of pipes circulating steam, hot oil, or hot water, or by electric blankets or heating elements on forms. Pipes, blankets, or elements shall not be in contact with concrete, form surfaces, or test cylinders.

During the cycle of radiant heat curing, effective means shall be provided to prevent rapid loss of moisture in any part of the member. Moisture may be applied by a cover of moist burlap or cotton matting. Moisture may be retained by covering the member with a plastic sheet in combination with an insulating cover or by applying a liquid seal coat, approved by the Engineer, or membrane curing compound.

To prevent cracking of members, strands shall be detensioned and their stress transferred to the concrete immediately upon attainment of required release strengths and before the members have been allowed to dry and cool. Should this be impractical, the members shall be kept covered and moist and shall be held at a minimum temperature of 60°F until strands are detensioned.

If the contractor proposes to cure by any other method, the method and its details shall be subject to the approval of the Engineer.

553.13 Bonding Steel

Unless otherwise SHOWN ON THE DRAWINGS, steel shall be bonded to the concrete.

553.14 Finishing

Unless otherwise SHOWN ON THE DRAWINGS, the exterior surface of the exterior girders and the bottom flanges of all girders shall be given a Class 2 Rubbed Finish as specified in Subsection 552.13. The rest of the girders shall be given a Class 1 Ordinary Surface finish.

Portions of prestressed members that will serve as bridge decks will be finished as SHOWN ON THE DRAWINGS.

The contractor, with the approval of the Engineer, will be allowed to repair rock pockets and other minor deficiencies of a nonstructural nature in the girders. Any girders that are repaired without the approval of the Engineer may be rejected regardless of the extent of the repair work.

553.15 Handling

Extreme care shall be exercised in handling, moving, and erecting precast, prestressed concrete members. Precast girders and slabs shall be transported in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position.

Precast, prestressed concrete members shall not be shipped from the casting plant for at least 72 hours after the prestressing strands have been released or the curbs and/or diaphragms have been cured as specified in Subsection 553.12.

553.16
Erecting &
Placement

The contractor shall advise the Engineer a minimum of 48 hours before prestressed girders for multi-beam bridges are to be field welded, and before any field grout or mortar is to be placed.

If necessary, multi-beam girders shall be adjusted, using galvanized steel shims the same length and width as the bearing pad or plate. No more than 1/8 inch vertical difference shall exist between top of adjacent beam edges at each end of the span. When an asphalt wearing surface or cast-in-place deck is to be placed on top of the prestressed beams, this vertical tolerance may be 1/2 inch. Beams will not be loaded to make them assume the same camber as an adjacent beam.

Mortar shall be used in keyways between multi-beam members and to patch defects, blockouts, or other areas on the concrete roadway portion of the structure 1 inch or more depth and over 1 inch in width. Smaller areas on the concrete roadway shall be patched with the grout.

Air and concrete keyway temperatures shall be between 45 °F and 85 °F before placement of mortar. The temperature must be expected to remain within these limits until mortar placement and application of curing method is completed.

Grout shall be used on all anchor bolts and dowels to make all repairs.

Air and concrete temperatures required for grout placement shall be the same as required for mortar. The area to be grouted shall be thoroughly saturated with water and all free-standing water removed just prior to grout placement.

Exposed grout surface shall be struck off flush and given the same surface texture finish as the surrounding concrete as soon as the grout has set sufficiently. The exposed surface shall be cured as specified in Subsection 552.14. When artificial means are used to control the curing temperature of the mortar or grout, as in hot or cold weather, the means shall be approved by the Engineer in advance. Combustion heaters may be used only if fully vented outside their enclosure. All dry mortar materials and mixing and placing equipment shall be stored such that their temperature is above freezing. Mixing water may be warmed to provide mortar or grout at desired temperature, but shall be 90 °F or less when mixed with the dry materials. Ice may be used as part of the mixing water provided it is completely melted prior to the introduction of the water to the dry materials.

Patching mortar and grout shall be the same color as the parent concrete.

Precast prestressed concrete piling shall be placed in accordance with the requirements for precast concrete piling in Section 551. Other precast prestressed structural members shall be placed in the structure as SHOWN ON THE DRAWINGS and in accordance with contract provisions governing the particular type of structure to be built.

Field welding shall meet the requirements of Section 555. When welding or burning on precast members, the ground lead shall be attached directly to the base metal; if a precast prestressed member is used as a conductor for the ground, the member will be rejected and shall be replaced by the contractor without compensation.

MEASUREMENT

553.17
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS. Each member will include the concrete, reinforcement and prestressing steel, enclosures for prestressing steel, anchorages, plates, nuts, elastomeric bearing pads, and other material contained within or attached to the unit.

Piling will be measured as provided in Section 551.

PAYMENT

553.18 Basis The accepted quantities will be paid at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Pay Item		Pay Unit
553(01)	Prestressed Concrete Structural Member _____ (Identification).	EA.
553(02)	Prestressed Concrete Structure	L.S.

Section 553A - Precast Concrete Structures

DESCRIPTION

553A.01
Work

This work shall consist of the construction of precast concrete portions of composite structures. The work shall also include manufacture, materials testing, transportation, storage, and installation of all precast concrete portions, except piling, including all necessary grouting, welding, or other connections. Precast concrete members shall be furnished complete, in place, including all concrete reinforcing steel, and incidentals connected therewith.

MATERIALS

553A.02
Requirements

Materials shall meet the requirements of the following Subsections:

Concrete	552.03-04
Reinforcing Steel	554.02
Grout and Mortar	701.02-03
Joint Fillers	705.01
Structural Steel	717.01
Hardware, Nuts, and Bolts	717.02-03
Elastomeric Bearing Pads	717.13

The contractor shall perform all sampling, testing, and inspection necessary to ensure quality control of the component materials and the concrete. Sampling and testing for quality control and acceptance testing shall be in accordance with the AASHTO or ASTM test methods prescribed in Section 552.

The contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantitites approved and rejected, and the nature of any corrective action taken.

Every batch shall be sampled and tested (100 percent sampling and testing) for air content and slump at the start of concrete production. Random sampling and testing for air content and slump at the rate of one for every five successive batches may be substituted for 100 percent sampling and testing if the test results for three successive batches are within the specification limitations for air content or slump, except that 100 percent sampling and testing will be reinstated if a test result for any random sample is outside the specification limitations for either air content or slump.

Compression tests to determine the minimum strength requirements shall be made on cylinders. A minimum of three cylinders will be made from each day's production and cured in the same manner as the precast units. Testing methods shall be in accordance with AASHTO T 22.

The contractor or the supplier shall furnish the Engineer with a Certificate of Compliance certifying that the above materials comply with the applicable contract specifications. A copy of all test results performed by the contractor or supplier necessary to ensure contract compliance shall also be furnished to the Engineer.

CONSTRUCTION

553A.03
Performance

Precast Concrete Structural Members shall be constructed in accordance with the applicable Sections of the following:

Concrete	552
Curing	552.14
Steam Curing or Radiant Heat	553.12

Finishing	553.14
Handling	553.15
Erecting and Placement	553.16
Reinforcing Steel	554

Four sets of shop drawings or two sets plus one reproducible set shall be submitted to the Engineer for approval, including the concrete mix design for each class of concrete proposed for use, a minimum of 21 days in advance of fabrication of the precast member(s).

553A.04
Casting Yard

The precasting of concrete structural members may be done at a location selected by the contractor.

MEASUREMENT

553A.05
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Each member will include the concrete, reinforcement steel, anchorages, plates, nuts, and other material contained within or attached to the unit.

PAYMENT

553A.06
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Pay Item		Pay Unit
553A(01)	Precast Concrete Structural Member _____	EA
553A(02)	Precast Concrete Structure	L.S.

Section 554 - Reinforcing Steel

DESCRIPTION

554.01
Work

This work shall consist of furnishing and placing reinforcing steel of the shape and dimensions SHOWN ON THE DRAWINGS.

MATERIALS

554.02
Requirements

Reinforcing steel and metal supports shall meet the requirements of Subsection 709.01. The grade of reinforcing steel shall be Grade 60 unless otherwise SHOWN ON THE DRAWINGS or the SPECIAL PROJECT SPECIFICATIONS.

CONSTRUCTION

554.03
Order Lists

When SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS, all order lists and bending diagrams shall be submitted to the Engineer. Inspection of the reinforcing steel will be made after installation and prior to placing concrete.

554.04
Protection of Materials

Reinforcing steel shall be protected at all times from damage by storing on blocking racks or platforms. Prior to placing concrete, reinforcing steel that is to be embedded shall be free from rust that pits the surface or scales off, dirt, mud, loose mill scale, paint, oil, grease, or any other foreign substance.

554.05
Cutting & Bending

Cutting and bending of reinforcing bars shall be in accordance with the Manual of Standard Practice published by the CRSI, or ACI Detailing Manual SP-66, unless otherwise detailed. Bars partially embedded in concrete shall not be bent except as SHOWN ON THE DRAWINGS.

554.06
Placing & Fastening

Reinforcing steel shall be accurately placed as SHOWN ON THE DRAWINGS and shall be firmly and securely held in position by wiring at intersections and splices, and by using precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires, and other devices approved by the Engineer of sufficient strength to resist crushing under applied loads. Ferrous metal chairs that extend to within 1/2 inch of the surface shall have epoxy coated feet or be galvanized, or made of stainless steel. Supports made from wood, aluminum, plastic, brick, or rock shall not be used. For epoxy-coated reinforcing bars, use nylon-coated tie wires. Bar supports for epoxy-coated reinforcing bars shall be epoxy or plastic coated.

Unless otherwise SHOWN ON THE DRAWINGS, bars shall be lapped in accordance with the Building Code Requirements for Reinforced Concrete, ACI 318-83, Chapter 12, as published by the American Concrete Institute.

Main reinforcement shall be spliced only where SHOWN ON THE DRAWINGS. All welds shall meet the requirements of AWS D1.4-79.

Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted.

All reinforcement shall have a clear coverage of 2 inches, except as SHOWN ON THE DRAWINGS or specified herein.

In bridge decks, reinforcing shall be fastened at alternate intersections unless this results in ties being more than 12 inches apart, in which case, each intersection shall be tied. All intesections at the outside edges of decks shall be tied. In precast and/or prestressed concrete units, every reinforcing steel intersection shall be tied.

For a protective concrete covering of 1 to 3 inches, reinforcing steel may have an allowable concrete cover variation of 1/4 inch; for a protective concrete covering of 3 inches or more, a 1/2 inch variation in protective cover is allowed. Additionally, the allowable variation for center-to-center spacing and location of reinforcing steel shall be as follows, unless otherwise noted:

Center-to-center spacing of all bars	±1/2 inch parallel to the nearest surface.
Location of any bar	±1 inch parallel to the nearest surface.

Tack welding in lieu of wire ties will not be permitted. However, tack welding of nonstressed reinforcing bars in prestressed concrete that secure inserts, void ducts, and so forth, may be allowed when SHOWN ON THE DRAWINGS, or permitted in writing by the Engineer. In any case, all welding must be done prior to tensioning of the prestressing steel.

MEASUREMENT

554.07
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

The weights of reinforcing steel calculated will be based upon the following table:

Bar Size	Weight per Linear Foot in Pounds
#3	0.376
#4	0.668
#5	1.043
#6	1.502
#7	2.044
#8	2.670
#9	3.400
#10	4.303
#11	5.313
#14	7.650
#18	13.600

Approved splices added for the contractor's convenience will not be included in the quantity for payment.

PAYMENT

554.08
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
554(01)	Reinforcing Steel	LBS.
554(02)	Reinforcing Steel	L.S.

Section 555 - Steel Structures

DESCRIPTION

555.01
Work

This work shall consist of furnishing and constructing steel structures and the steel structure portions of composite structures.

The work will include the furnishing, fabricating, erecting, and painting of structural metals. Structural metals will include structural, welding, special, and alloy steels; metallic electrodes; steel forgings and castings; and iron castings.

MATERIALS

555.02
Requirements

Materials shall meet the requirements of the following Subsections:

Paint	708.03
Structural Steels	717.01
Bolts and Nuts	717.02
High-Tensile-Strength Bolts	717.03
Forgings	717.05
Pins and Rollers	717.06
Castings	717.07
Steel Grid Floors	717.08
Steel Pipe	717.09
Galvanized Metal	717.10
Sheet Lead	717.11
Welded Stud Shear Connectors	717.12
Elastomeric Bearing Pads	717.13
Structural Aluminum Alloy	717.14
Aluminum Alloy Materials for Bridge Rail	717.15
Aluminum Alloy Bolts and Nuts	717.16
Aluminum Alloy Welding Wire	717.17

555
.01

CONSTRUCTION

555.03
Shop Drawings
& Inspection

The contractor shall give the Engineer a 30-day notice prior to the beginning of work in the shop so that inspection may be provided.

The contractor shall submit four sets of shop drawings or two sets plus one reproducible set of same of the structural steel work to the Engineer for approval. The shop drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer without delaying the work. Such time shall be proportional to the complexity of the work, but in no case shall such time be less than 21 days.

The shop drawings shall show any changes proposed in the work, details for connections not dimensioned or otherwise SHOWN ON THE DRAWINGS, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout drawing of the entire structure, the location of any temporary supports that are to be used, and the vertical alignment of the steel work at each stage of the erection. Substantiating camber calculations shall be submitted with the shop drawings.

555.04
Fabrication

These specifications apply to bolted and welded construction.

Workmanship and finish shall be in accordance with the best general practice in modern bridge shops. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

Structural material, either plain or fabricated, shall be stored above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease, or other foreign matter, and shall be protected as far as practicable from corrosion.

Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends will be cause for rejection of the material.

Preparation of material shall be in accordance with AWS D1.1, paragraph 3.2, as modified by AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.

555.05 Finishing & Shaping

Finished members shall be true to line and free from twists, bends, and open joints.

(a) Edge Planing. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stresses shall be planed to a depth of 1/4 inch. Reentrant cuts shall be filleted before cutting.

(b) Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the following American National Standards Institute surface roughness requirements as defined in ANSI B46.1-47, Surface Roughness, Waviness, and Lay, Part I:

Steel Slabs	ANSI 2,000
Heavy Plates in Contact in Shoes To Be Welded	ANSI 1,000
Milled Ends of Compression Members, Stiffeners, and Fillers	ANSI 500
Bridge Rollers and Rockers	ANSI 250
Pins and Pin Holes	ANSI 125
Sliding Bearings	ANSI 125

(c) Abutting Joints. Abutting joints in compression members and girder flanges, and in tension members where SHOWN ON THE DRAWINGS, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/4 inch.

(d) End Connection Angles. Floor beams, stringers, and girders having end connection angles shall be built to drawing length back to back of connection angle with a permissible tolerance of plus zero to minus 1/16 inch. If end connections are faced, the finished thickness of the angles shall not be less than that SHOWN ON THE DRAWINGS, but in no case less than 3/8 inch.

(e) Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

(f) Web Plates (Bolted). In girders having no cover plates and not to be encased in concrete, the top edge of the web shall not extend above the backs of the flange angles and shall not be more than 1/8 inch below at any point. Any portion of the plate projection beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be not more than 1/2 inch less in width than the distance back to back of flange angles.

Splices in webs of girders without cover plates shall be sealed on top with red lead paste prior to painting.

At web splices, the clearance between the ends of the web plates shall not exceed 3/8 inch. The clearance at the top and bottom ends of the web splice plates shall not exceed 1/4 inch.

(g) Bent Plates. Cold-bent, load-carrying, rolled-steel plates shall meet the following requirements:

(1) They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling.

(2) The radius of bends shall ensure that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in the following table for all grades of structural steel in this specification:

Plate Thickness in Inches	Up to 1/2	Over 1/2 to 1	Over 1 to 1-1/2	Over 1-1/2 to 2-1/2	Over 2-1/2 to 4
Minimum Bend Radius	2t	2-1/2t	3t	3-1/2t	4t

Note: Low-alloy steel in thickness of over 1/2 inch may require hot bending for small radii.

Allowance for springback of ASTM A 514 and A 517 steels should be approximately three times that for structural carbon steel. For brake press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1,200 °F, except for ASTM A 514 and A 517 steels. If ASTM A 514 and A 517 steel plates or shapes are bent at a temperature greater than 1,125 °F, they must be requenched and tempered in accordance with the producing mill's practice. Hot-bent plates shall meet requirement (1) above.

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(3) Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout that portion of the plate where the bending is to occur.

(h) Fit of Stiffeners. End stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing (either milled, ground, or on weldable steel in compression areas of flanges, welded as SHOWN ON THE DRAWINGS) on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless SHOWN ON THE DRAWINGS or specified otherwise, fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

Welding will be permitted instead of milling or grinding if SHOWN ON THE DRAWINGS or SPECIAL PROJECT SPECIFICATIONS. Brackets, clips, gussets, stiffeners, and other detail material shall not be welded to members or parts subjected to tensile stress unless approved by the Engineer.

(i) Eyebars. Pin holes may be flame cut at least 2 inches smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together in the order that they will be placed on the pin and bored at both ends while so clamped. Eyebars shall be packed and match marked for shipment and erection. All identifying marks shall be stamped with steel stencils on the edge of one head of each member after fabrication is completed so that the marks will be visible when the bars are nested in place on the structure. The eyebars shall be straight and free from twists, and the pin holes shall be accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/16 inch per foot.

The edges of eyebars that lie between the transverse centerline of their pin holes shall be cut simultaneously with two mechanically operated torches abreast of each other, guided by a substantial template, in a manner that will prevent distortion of the plates.

(j) Annealing and Stress Relieving. Structural members that are SHOWN ON THE DRAWINGS to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and annealing (full annealing) shall be in accordance with ASTM E 44. The temperatures shall be maintained uniformly throughout the furnace during heating and cooling so the temperature at any two points on the member will not differ by more than 100 °F at any one time.

Members of ASTM A 514 and A 517 steels shall not be annealed or normalized and shall be stress relieved only with the approval of the Engineer.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instruments, including recording pyrometers, shall be provided for determining at any time the temperatures of members in the furnace. The records of the treatment operation shall be available to and meet the approval of the Engineer.

Members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plates together shall be stress relieved in accordance with Subsection 555.12 when SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

(k) Tests. When full-size tests of fabricated structural members or eyebars are required by the specifications, the number and nature of the tests, the results to be attained, and the measurements of strength, deformation, or other performances that are to be made will be SHOWN ON THE DRAWINGS or stated in SPECIAL PROJECT SPECIFICATIONS. The contractor shall provide suitable facilities, material, supervision, and labor necessary for making and recording the tests. The members tested in accordance with the contract will be measured in accordance with Subsection 555.26. The cost of testing, including equipment, handling, supervision, labor, and incidentals for making the tests, shall be included in the contract price for the fabrication or fabrication and erection of structural steel, whichever is the applicable pay item in the contract, unless otherwise specified.

555.06
Pins & Rollers

Pins and rollers shall be accurately turned to the dimensions SHOWN ON THE DRAWINGS and shall be straight, smooth, and free from flaws. Pins and rollers more than 9 inches in diameter shall be forged and annealed. Pins and rollers 9 inches or less in diameter may be either forged and annealed or cold-finished, carbon-steel shafting.

In pins larger than 9 inches in diameter, a hole not less than 2 inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent damage by too rapid cooling, and before being annealed.

Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles to the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than 1/32 inch. Boring of holes in built-up members shall be done after the bolting is completed.

The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter, or 1/32 inch for larger pins.

Two pilot nuts and two driving nuts for each size of pin shall be furnished.

555.07
Fastener Holes

All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the fasteners whenever the thickness of the metal is not greater than 3/4 inch for structural steel or 5/8 inch for alloy steel.

When there are more than five thicknesses or when any of the main material is thicker than 3/4 inch (structural steel) or 5/8 inch (alloy steel), or when required under other provisions of this subsection, all the holes shall be subpunched or subdrilled 3/16 inch smaller than the nominal diameter of the fasteners. After assembling, holes shall be reamed 1/16 inch larger or drilled from the solid to 1/16 inch larger than the nominal diameter of the fasteners. For punched holes, the diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. If any holes must be enlarged to admit the fasteners, they shall be reamed. Holes shall be clean cut, without torn or ragged edges. Poor matching of holes will be cause for rejection.

Reamed holes shall be cylindrical, perpendicular to the member, and not more than 1/16 inch larger than the nominal diameter of the fasteners. Where practicable, reamers shall be directed by mechanical means. Drilled holes shall be 1/16 inch larger than the nominal diameter of the fasteners. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match marked before disassembling.

Unless otherwise specified, holes for all field connections and field splices of main truss or arch members, continuous beams, towers (each face), bents, plate girders, and rigid frames shall be subpunched (or subdrilled if subdrilling is required) and subsequently reamed while assembled in the shop in accordance with Subsection 555.08.

All holes for floor beam and stringer field end connections shall be subpunched and reamed to a steel template while assembled.

Reaming or drilling full size of field connections through templates shall be done after the templates have been positioned and angled with the utmost accuracy and firmly bolted in place. Templates used for the reaming of matching members, or of the opposite faces of one member, shall be exact duplicates. Templates for connections that duplicate shall be so accurately located that like members are duplicates and require no matchmarking.

All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole can be entered perpendicular to the face of the member without drifting, in at least 75 percent of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin 3/16 inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thickness of metal.

All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. The centerlines shall be used in locating accurately the template from the milled or scribed ends of the members.

555.08
Shop Assembly

(a) Fitting for Bolting. Surfaces of metal in contact with each other shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming is commenced. Assembled pieces shall be taken apart if necessary for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformation.

Preparatory to the shop bolting of full-sized punched material, the bolt holes, if necessary, shall be spear reamed for the admission of the bolts. The reamed holes shall not be more than 1/16 inch larger than the nominal diameter of the bolts.

End connection angles, stiffener angles, and similar parts shall be carefully adjusted to correct positions and bolted, clamped, or otherwise firmly held in place until permanently connected.

Parts not completely bolted in the shop shall be secured by temporary bolts, insofar as practicable, to prevent damage in shipment and handling.

(b) Shop Assembling. The field connections of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing, and then shall have their subsize holes reamed to the specified size while the connections are assembled. Assembly shall be "Full Truss or Girder Assembly" unless "Progressive Truss or Girder Assembly," "Full Chord Assembly," "Progressive Chord Assembly," or "Special Complete Structure Assembly" is specified in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS. Methods of assembly shall be as described below:

(1) "Full Truss or Girder Assembly" shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at one time.

(2) "Progressive Truss or Girder Assembly" shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame all members in at least three contiguous shop sections or panels, but not less than the number of panels associated with three contiguous chord lengths (that is, length between field splices), and not less than 150 feet in the case of structures longer than 150 feet. At least one shop section or panel, or as many panels as are associated with a chord length, shall be added at the advancing end of the assembly before any member is removed from the rearward end so that the assembled portion of the structure is never less than that specified above.

(3) "Full Chord Assembly" shall consist of assembling (with geometric angles at the joints) the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower; reaming their field connection holes while the members are assembled; and reaming the web member connections to steel templates set at geometric (not cambered) angular relation to the chord lines. Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member and the templates at both ends of the member shall be accurately located from one of the milled ends or scribed lines.

(4) "Progressive Chord Asssembly" shall consist of assembling contiguous chord members in the manner specified for "Full Chord Assembly" and in the number and length specified for "Progressive Truss" or "Girder Assembly."

(5) "Special Complete Structure Assembly" shall consist of assembling the entire structure, including the floor system. (This procedure is ordinarily needed only for complicated structures such as those having curved girders or extreme skew in combination with severe grade or camber.) The assembly, including camber, alinement, accuracy of holes, and fit of milled joints, shall be approved by the Engineer before reaming is commenced.

A camber diagram shall be furnished to the Engineer by the contractor showing the camber at each panel point of each truss, arch rib, continuous beam line, plate girder, or rigid frame. When shop assembly is "Full Truss or Girder Assembly" or "Special Complete Structure Assembly," the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly is used, the camber diagram shall show calculated camber.

555.09
(Reserved)

555.10
Bolted Connections, Unfinished, Turned, & Ribbed Bolts

(a) General. Bolts under this article shall meet the requirements of "Specification for Carbon Steel Externally and Internally Threaded Standard Fasteners," ASTM A 307. Specifications for high-strength bolts are covered under Subsection 555.11.

Bolts shall be unfinished, turned, or an approved form of ribbed bolt with hexagonal nuts and heads, except that ribbed bolts shall have button heads. Bolted connections shall be used only as SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Bolts not tightened to the proof load shall have single self-locking nuts or double nuts. Bevel washers shall be used where bearing faces have a slope of more than 1 to 20 with respect to a plane normal to the bolt axis. Bolts shall be long enough to extend entirely through their nuts, but not more than 1/4 inch beyond them.

Bolts shall be driven accurately into the holes without damage to the threads. A snap shall be used to prevent damage to the heads. The heads shall be drawn tight against the work with full effort of a man using a suitable wrench not less than 15 inches long for bolts of nominal 3/4 inch diameter and over. Heads of bolts shall be tapped with a hammer while the nuts are being tightened.

(b) Unfinished Bolts. Unfinished bolts shall be furnished unless other types are specified. The number of bolts furnished shall be 5 percent more than the actual number SHOWN ON THE DRAWINGS for each size and length.

(c) Turned Bolts. The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed to provide a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

(d) Ribbed Bolts. The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads meeting the requirements of ANSI B18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The ribs shall be sufficiently hard so that they do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement. The contractor shall provide oversized bolts and nuts for this replacement in an amount not less than 10 percent of the number of ribbed bolts specified.

555.11 Bolted Connections, High-Tensile-Strength Bolts

(a) Bolts. Bolts shall meet the requirements of AASHTO M 164. Other fasteners that meet the chemical requirements of AASHTO M 164, that meet the mechanical requirements of AASHTO M 164 in full-size tests, and that have a body diameter and bearing areas under the head and nut not less than those provided by a bolt and nut of the same nominal dimensions prescribed above, may be used subject to the approval of the Engineer.

Bolt lengths shall be determined by adding the grip-length values given in table 555-1 to the total thickness of connected material. The values of table 555-1 compensate for manufacturer's tolerance; the use of a heavy, semifinished hexagon nut; and a positive "stick-through" at the end of the bolt. For each hardened flat washer that is used, add 5/32 inch to the tabular value and for each beveled washer add 5/16 inch. The length determined should be adjusted to the next longer 1/4 inch.

(b) Parts and Assembly. Bolted parts shall fit solidly together when assembled. Contact surfaces, including those adjacent to the washers, shall be descaled or carry the normal tight mill scale. Contact surfaces shall be free of dirt, oil, loose scale, burrs, pits, and other defects that would prevent solid seating of the parts.

Contact surfaces of joints shall be free of paint, lacquer, galvanizing, or rust inhibitor unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

Table 555-1.--Bolt length.

Bolt Size in Inches	To Determine Required Bolt Length, Add Grip, in Inches[a]
1/2	11/16
5/8	7/8
3/4	1
7/8	1-1/8
1	1-1/4
1-1/8	1-1/2
1-1/4	1-5/8
1-3/8	1-3/4
1-1/2	1-7/8

[a] Does not include allowance for washer thickness.

Connections shall be assembled with a hardened washer under the element (nut or bolt head) turned in tightening. Where an outer face of the bolted parts has a slope of more than 1 to 20 with respect to a plane normal to the bolt axis, a smooth-beveled washer shall be used to compensate for the lack of parallelism. In all cases of only one nonsloping surface, the turned element shall be adjacent to this surface. Where clearance is necessary, washers may be clipped on one side to a point not closer than seven-eighths of the bolt diameter from the center of the washer.

(1) Installation. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in table 555-2 for the size and grade of fastener used.

Table 555-2.--Bolt tension (AASHTO M 164 bolts).

Bolt Size (Inches)	Minimum Bolt Tension[a] (Pounds)
1/2	12,050
5/8	19,200
3/4	28,400
7/8	39,250
1	51,500
1-1/8	56,450
1-1/4	71,700
1-3/8	85,450
1-1/2	104,000

[a] Equal to the Proof Load (Length Measurement Method) given in AASHTO M 164.

Threaded bolts shall be tightened with properly calibrated wrenches, by the turn-of-nut method, a direct tension indicator, or other method approved by the Engineer. If required because of bolt entering and/or wrench operation clearances, tightening by any procedure may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

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.11

When calibrated wrenches are used to provide the bolt tension specified in table 555-2, their setting shall be sufficient to induce a bolt tension 5 to 10 percent in excess of this value. These wrenches shall be calibrated at least once each working day by tightening, in a device capable of indicating actual bolt tension, not less than three typical bolts of each diameter from the bolts to be installed. Power wrenches shall be adjusted to stall or cutout at the selected tension. If manual torque wrenches are used, the torque indicator corresponding to the calibrating tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in tightening motion when torque is measured. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which might have been loosened by the tightening of subsequent bolts, until all are tightened to the prescribed amount.

When the turn-of-nut method is used to provide the bolt tension in lieu of that specified in table 555-2, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into full contact with each other. "Snug tight" shall be defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally to the applicable amount of nut rotation specified in table 555-3 with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench.

Table 555-3.--Nut rotation[a] from snug tight condition.

Bolt Length (Measured from Underside of Head to Extreme End of Point)	Disposition of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis and Other Face Sloped not More Than 1:20 (Bevel Washer Not Used)	Both Faces Sloped Not More than 1:20 from Normal to Bolt Axis (Bevel Washers Not Used)
Up to and Including 4 Diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 Diameters but not Exceeding 8 Diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 Diameters but not Exceeding 12 Diameters[b]	2/3 turn	5/6 turn	1 turn

[a] Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance is plus or minus 30°; for bolts installed by 2/3 turn and more, the tolerance is plus or minus 45°

[b] The required rotation must be determined by actual tests in a suitable tension device simulating the actual conditions.

(2) Inspection.

a. When the calibrated-wrench method of tightening is used, the Engineer shall have full opportunity to witness the calibration tests.

b. The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are tightened.

c. The following inspection shall be used unless a more extensive or different procedure is specified:

In the presence of the Engineer, the contractor shall use an inspecting wrench which may be either a torque wrench or a power wrench that can be accurately adjusted in accordance with Subsection 555.11(b)(1) above.

Three bolts of the same grade, size, and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. Length shall be representative of bolts used in the structure. There shall be a washer under the part turned in tightening each bolt.

When the inspecting wrench is a torque wrench, each of the three bolts specified above shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in table 555-2. The inspecting wrench shall then be applied to the tightened bolt and the torque necessary to run the nut or head 5 degrees (approximately 1 inch at 12-inch radius) in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspection torque to be used in the manner specified_below.

When the inspecting wrench is a power wrench, it shall be adjusted so that it will tighten each of the three bolts specified to a tension of at least 5 percent but not more than 10 percent greater than the minimum tension specified for its size in table 555-2. This setting of wrench shall be taken as the job-inspecting torque to be used in the manner specified below.

Bolts, represented by the three sample bolts prescribed above, that have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench at its job-inspecting torque to 10 percent of the bolts, but not less than two bolts selected at random in each connection. If no nut or bolt head is turned by this application of the job-inspecting torque, the connection shall be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job-inspecting torque shall be tightened and reinspected, or alternatively, the fabricator or erector may elect the option to retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

(3) Reuse. High-strength bolts, nuts, and washers shall not be reused. Retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts is not considered reuse.

555.12 Welding

Welding shall be done in accordance with the best modern practice and the applicable requirements of AWS D1.1 except as modified by AASHTO's "Standard Specifications for Welding of Structural Steel Highway Bridges."

555.13 Erection

The contractor shall provide the falsework and all tools, machinery, and appliances, including driftpins and fitting-up bolts, necessary for the expeditious handling of the work, and shall erect the metal work, remove the temporary construction, and do all work necessary to complete the structure.

555.14 Handling & Storing Materials

Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, the contractor shall check the material turned over to him against the shipping lists and report promptly in writing any shortage or injury discovered. The contractor shall be responsible for the loss of any material, or for any damage caused to it after being received.

555.15 Falsework

The falsework shall be properly designed and substantially constructed and maintained for the loads that it will bear. The contractor shall prepare and submit to the Engineer construction drawings for falsework and working drawings for changes in any existing structure necessary for maintaining traffic.

555.16 Method & Equipment

Before starting the work of erection, the contractor shall fully inform the Engineer of the proposed method of erection and the amount and character of equipment to be used.

555.17 Straightening Bent Materials

The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted in writing by the Engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry-red color. After heating, the metal shall be cooled as slowly as possible.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture. Fractured material will be rejected.

555.18 Assembling Steel

The parts shall be accurately assembled as per the shop drawings, and any matchmarks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering that will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking placed to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully connnected with permanent fasteners and all other truss connections pinned and erection bolted. Splices of butt joints of compression members that are milled to bear and of railing shall not be permanently fastened until the spans have been swung, except that such permanent fastening may be accomplished for the truss members at any time that joint holes are fair. Splices and field connections shall have one-half of the holes filled with erection bolts and cylindrical erection pins (half bolts and half pins) before placing permanent fasteners. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the permanent fasteners, and cylindrical erection pins will be 1/16 inch larger.

555.19 (Reserved)

555.20 Pin Connections

Pilot and driving nuts shall be used in driving pins. They shall be furnished by the contractor without charge. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed tight and the threads burred at the face of the nut with a pointed tool.

555.21 Setting Shoes & Bearings

Shoes and bearing plates shall not be placed on bridge seat bearing areas that are improperly finished, deformed, or irregular. They shall be set level in exact position and shall have full and even bearing. The shoes and bearing plates may be set by either of the following methods:

(a) The bridge seat bearing area shall be heavily coated with mastic and then covered with three layers of 12- to 14-ounce duck, each layer being coated thoroughly on its top surface with mastic. The shoes and bearing plates shall be placed in position while the mastic is plastic.

As alternatives to canvas and mastic, and when SHOWN ON THE DRAWINGS, the following may be used:

(1) Sheet lead of the DESIGNATED thickness.

(2) A preformed fabric pad composed of multiple layers of 8-ounce duck, impregnated and bound with high-quality natural rubber or of equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be sufficient to produce the specified thickness after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 pounds per square inch, without detrimental reduction in thickness or extension.

(3) Elastomeric bearing pads.

(b) The shoes and bearing plates shall be properly supported and fixed with approved nonshrink grout. No load shall be placed on them until the grout has cured in accordance with the manufacturer's instructions for at least 96 hours.

The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond to the temperature at the time of erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

555.22 Preparing Metal Surfaces for Painting

All surfaces of new structural steel that are to be painted shall be blast cleaned unless otherwise specified in the SPECIAL PROJECT SPECIFICATIONS. Where partial cleaning is required in repainting existing structures, the method of cleaning will be specified in the SPECIAL PROJECT SPECIFICATIONS. The steel surfaces to be painted shall be prepared as outlined in the Steel Structures Painting Council (SSPC) specifications, meeting one of the following classes of surface preparation:

(a) SSPC-SP-5 White Metal Blast Cleaning

(b) SSPC-SP-6 Commercial Blast Cleaning

(c) SSPC-SP-8 Pickling

(d) SSPC-SP-10 Near-White Blast Cleaning

Corrosion-resistant (high-strength weathering) steel shall be blast cleaned as provided in SSPC-SP-6 Commercial Blast Cleaning. The surfaces to be cleaned shall be specified in the SPECIAL PROJECT SPECIFICATIONS.

Blast cleaning shall leave all surfaces with a dense and uniform anchor pattern of not less than 1-1/2 mils measured with an approved surface profile comparator or Testx Presse Tape.

Blast-cleaned surfaces shall be primed or treated the same day blast cleaning is done. If cleaned surfaces rust or are contaminated with foreign material before painting is accomplished, they shall be recleaned by the contractor.

When paint systems Number 1 or Number 3 are specified, the steel surfaces shall be blast cleaned in accordance with SSPC-SP-10; otherwise, blast cleaning shall meet the requirements of SSPC-SP-6.

555.23 Systems of Paint

The paint system to be applied shall consist of one as set forth in table 555-4.

Table 555-4.--Paint systems.

Environment[b]	Paint System[a]				
	1	2	3	4	5
High Pollution or Coastal	X	X	X		
Mild Climate				X	X

[a] Paint system shown for severe areas are satisfactory in less severe areas.

[b] Coastal--within 1,000 feet of ocean or tidal water. High pollution--air pollution environment such as industrial areas. Mild--other than coastal areas not in air pollution environment.

All structural steel shall be painted by one of the following systems. The required system or choice of systems including the color of the final coat will be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

System 4 is intended for use in mild climates or to repaint existing structures where the other systems are not compatible.

Coating	Subsection	Min. Dry Film Thickness (Mils)
System 1--Vinyl Paint System		
Wash primer	708.03(b)	0.5
Intermediate coat	708.03(b)	1.5-2.0
3rd coat	708.03(b)	1.5-2.0
4th coat	708.03(b)	1.5-2.0
Final coat	708.03(b)	1.5-2.0
	Total Thickness	6.5-8.5
System 2--Epoxy-Polyamide System		
Primer coat	708.03(c)	2.0-3.0
Intermediate coat	708.03(c)	2.0-3.0
3rd coat[a]	708.03(c)	2.0-3.0
Final coat	708.03(c)	1.5-2.0
	Total Thickness	7.5-11.0
System 3--Inorganic Zinc Silicate System		
Primer	708.03(d)	3.5-5.0
Intermediate coat	708.03(d)	1.0-2.0
Final coat	708.03(d)	3.0 min
	Total Thickness	7.5-10.0
System 4--Alkyd-Oil Basic Lead Silico-Chromate System[b]		
Primer coat	708.03(e)	2.0-3.0
Intermediate coat	708.03(e)	2.0-3.0
Final coat	708.03(e)	2.0-3.0
	Total Thickness	6.0-9.0
System 5--Organic Zinc-Rich Paint System		
Primer coat	708.03(f)	1.5-2.0
Intermediate coat	708.03(f)	2.0-2.5
Wash prime tie coat	708.03(f)	0.5
Final coat	708.03(f)	1.5-2.0
	Total Thickness	5.5-7.0

[a] The third coat may be eliminated in mild climates.

[b] This paint system may be specified as four coats for new structural steel, in mild climates, with a minimum thickness of 6.0 mils.

555.24 Painting Metal Surfaces

(a) Time of Application. The prime coat of paint, or pretreatment when specified, shall be applied as soon as possible after the surface has been cleaned and before deterioration of the surface occurs. Any oil, grease, soil, dust, or foreign matter deposited on the surface after the surface preparation is completed shall be removed prior to painting. In the event rusting occurs after completion of the surface preparation, the surfaces shall be cleaned again.

Particular care shall be taken to prevent the contamination of cleaned surfaces with salts, acids, alkali, or other corrosive chemicals before the prime coat is applied and between applications of the remaining coats of paint. Such contaminants shall be removed from the surface. Under these circumstances, the pretreatments or, in the absence of a pretreatment, the prime coat of paint shall be applied immediately after the surface has been cleaned.

(b) Storage of Paint and Thinner. Preferably, all paint and thinner should be stored in a separate building or room that is well ventilated and free from excessive heat, sparks, flame, or the direct rays of the sun. Paints susceptible to damage from freezing shall be kept in a heated storage space when necessary.

All containers of paint should remain unopened until required for use.

Paint that has livered, jelled, or otherwise deteriorated during storage shall not be used. Thixotropic materials that can be stirred to attain normal consistency are satisfactory.

(c) Mixing and Thinning. All ingredients in any container of paint shall be thoroughly mixed before use and shall be agitated often enough during application to keep the pigment in suspension.

Paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the vehicle. This does not imply that part of the vehicle cannot be poured off temporarily to simplify the mixing.

Mixing shall be by mechanical methods, except that hand mixing will be permitted for containers up to 5 gallons in size.

Mixing in open containers shall be done in a well-ventilated area away from sparks or flames.

Paint shall not be mixed or kept in suspension by means of an air stream bubbling under the paint surface.

Where a skin has formed in the container, the skin shall be cut loose from the sides of the container, removed, and discarded. If such skins are thick enough to have a practical effect on the composition and quality of the paint, the paint shall not be used.

The paint shall be mixed in a manner that will ensure breaking up of all lumps, complete dispersion of settled pigment, and a uniform composition. If mixing is done by hand, most of the vehicle shall be poured off into a clean container. The pigment in the paint shall be lifted from the bottom of the container with a broad, flat paddle; lumps shall be broken up; and the pigment shall be thoroughly mixed with the vehicle. The poured-off vehicle shall be returned to the paint with simultaneous stirring or pouring from one container to another until the composition is uniform. The bottom of the container shall be inspected for unmixed pigment.

Tinting pastes or colors shall be wetted with a small amount of thinner, vehicle, or paint and thoroughly mixed. The thinned mixture shall then be added to the large container of paint and mixed until the color is uniform.

Paint that does not have a limited pot life or does not deteriorate on standing may be mixed at any time before using, but if settling has occurred it must be remixed immediately before using. Paint shall not remain in the spray pots, painter's buckets, etc., overnight, but shall be gathered into a container and remixed before use.

No thinner shall be added to the paint unless necessary for proper application. In no case shall more than one pint of thinner be added per gallon unless the paint is intentionally formulated for greater thinning. The type of thinner shall comply with the paint specification.

When the use of thinner is permissible, thinner shall be added to paint during the mixing process. Painters shall not add thinner to paint after it has been thinned to the correct consistency. All thinning shall be done under supervision of one acquainted with the correct amount and type of thinner to be added to the paint.

(d) Application of Paint

(1) General. Paint shall be applied by brushing or spraying or by a combination of these methods. Daubers or sheepskins may be used when no other method is practicable for proper application in places of difficult access. Dipping, roller coating, or flow coating shall be used only when specifically authorized.

When two coats of the same color are to be applied, the first coat shall be tinted darker with an approved tinting material.

Open seams at contact surfaces of built-up members that would retain moisture shall be caulked with approved material before the second undercoat of paint is applied.

Paint shall not be applied when the surrounding air temperature is below 40 °F. Paint shall not be applied when the temperature is expected to drop to 32 °F before the paint has dried. Paint shall not be applied to steel that is more than 5 °F below the air temperature or that is at a temperature less than 40 °F. Paint shall not be applied when the steel surface is less than 5 °F above the dew point. Paint shall not be applied to steel at a temperature over 125 °F unless the paint is specifically formulated for application at the proposed temperature, nor shall paint be applied to steel which is at a temperature that will cause blistering or porosity or otherwise will be detrimental to the life of the paint. 555 .24

Paint shall not be applied in fog or mist, when it is raining or snowing, or when the relative humidity exceeds 85 percent. Paint shall not be applied to wet or damp surfaces. Paint shall not be applied on frosted or ice-coated surfaces.

When paint must be applied in damp or cold weather, the steel shall be painted under cover, or protected, or sheltered, or the surrounding air and the steel heated to a satisfactory temperature. In all such cases, the above temperature and humidity conditions shall be met. Steel shall remain under cover or be protected until dry or until weather conditions permit its exposure.

Any applied paint exposed to freezing, excess humidity, rain, snow, or condensation shall first be permitted to dry. Then, damaged areas of paint shall be removed, the surface again prepared, and repainted with the same number of coats of paint of the same kind as the undamaged areas.

If stripe painting is stipulated in the specifications or if the contractor chooses to do so, all edges, corners, crevices, bolts, welds, and sharp edges shall be painted with the priming paint by brush before the steel receives its first full prime coat of paint. Such striping shall extend for at least 1 inch from the edge. When practicable, this stripe coat shall be permitted to dry before the prime coat is applied; otherwise, the stripe coat shall set to touch before the full prime coat is applied. However, the stripe coat shall not be permitted to dry for a period long enough to allow rusting of the unprimed steel. When desired, the stripe coat may be applied after a complete prime coat.

To the maximum extent practicable, each coat of paint shall be applied as a continuous film of uniform thickness free of pores. Any thin spots or areas missed in the application shall be repainted and permitted to dry before the next coat of paint is applied.

Film thicknesses are included in the description of paint systems.

Each coat of paint shall be in a proper state of cure or dryness before the application of the succeeding coat.

(2) Brush Application. Paint shall be worked into all crevices and corners, and surfaces not accessible to brushes shall be painted by spray, daubers, or sheepskins. All runs or sags shall be brushed out. There shall be a minimum of brush marks left in the applied paint.

(3) Spray Application of Paint. The equipment used for spray application of paint shall be suitable for the intended purpose, shall be capable of properly atomizing the paint to be applied, and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of the equipment for the material being sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application. In closed or recirculating paint spray systems, where gas under pressure is used over the liquid, the gas shall be an inert one, such as nitrogen.

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.24

Traps or separators shall be provided to remove oil and water from compressed air. These traps or separators shall be of adequate size and shall be drained periodically during operations. The air from the spray gun impinging against the surface shall show no water or oil.

Paint ingredients shall be kept properly mixed in the spray pots or containers during paint application either by continuous mechanical agitation or by intermittent agitation as frequently as necessary.

The pressure on the material in the pot and of the air at the guns shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to atomize the paint properly but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or loss by overspray.

Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before applying paint to the surface being painted.

Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern shall be adjusted so that the paint is deposited uniformly. During application, the gun shall be held perpendicular to the surface and at a distance that will ensure that a wet layer of paint is deposited on the surface. The trigger of the gun should be released at the end of each stroke.

All runs and sags shall be brushed out immediately or the paint shall be removed and the surface repainted. Spray application of prime coats shall in all cases be immediately followed by brushing.

Areas inaccessible to the spray gun shall be painted by brush. If not accessible by brush, daubers or sheepskins shall be used. Brushes shall be used to work paint into cracks, crevices, and blind spots that are not adequately painted by spray.

(4) Shop Painting. Shop painting shall be done after fabrication and before any damage to the surface occurs from weather or other exposure. Shop contact surfaces shall not be painted unless specified.

Surfaces not to be in contact but that will be inaccessible after assembly shall receive either the full paint coats specified or three shop coats of the specified primer before assembly.

The areas of steel surfaces to be in contact with concrete shall not be painted. Unless otherwise SHOWN ON THE DRAWINGS, the areas of steel surfaces to be in contact with wood shall receive either the full paint coats specified or three shop coats of the specified primer.

If the paint would be harmful to a welding operator or would be detrimental to the welding operation or the finished welds, the steel shall not be painted within a suitable distance from the edges to be welded.

Antiweld spatter coatings shall be removed before painting. Weld slag and flux shall be removed by methods at least as effective as those specified for the cleaning.

Machine-finished or similar surfaces that are not to be painted but require protection shall be protected with a coating of rust inhibitive petroleum, or other coatings that may be more suitable for special conditions.

Erection marks and weight marks shall be copied on areas that have been previously painted with the shop coat.

(5) Field Painting. Steel structures shall be painted as soon as practicable after erection.

Metal that has been shop coated shall be touched up with the same type and brand of paint as the shop coat. This touch-up shall include cleaning and painting of field connections, welds, and all damaged or defective paint and rusted areas. The contractor may elect the option to apply an overall coat of primer in place of touch-up or spot painting.

Surfaces (other than contact surfaces) which are accessible before erection but which will not be accessible after erection shall receive all field coats of paint before erection.

If possible, the final coat of paint shall not be applied until all concrete work is finished. If concreting or other operations damage any paint, the surface shall be cleaned and repainted. All cement or concrete spatter and drippings shall be removed before any paint is applied.

Wet paint shall be protected against damage from dust or other detrimental foreign matter.

(6) Drying of Painted Metal. The maximum time specified by the manufacturer shall be allowed for paint to dry before

recoating or exposure. No drier shall be added to paint on the job unless specifically called for in the specifications for the paint. No painted metal shall be subjected to immersion before the paint is dried through. Paint shall be protected from rain, condensation, contamination, snow, and freezing until dry.

(7) Handling of Painted Steel. Painted steel shall not be handled until the paint has dried, except for necessary handling in turning for painting or stacking for drying.

Painted surfaces that are damaged in handling shall be scraped off and touched up with the same number of coats and kinds of paint as were previously applied to the steel.

Painted steel shall not be loaded for shipment or shipped until it is dry.

(e) Measurement of Dry Film Thickness of Paints

(1) Instrumentation. Dry paint film thicknesses will be measured using pull-off (Type 1) or fixed-probe (Type 2) magnetic gauges. Type 1 gauges include Tinsley, Elecometer, Microtest, and Inspector models. Type 2 gauges include Elcometic, Minitector, General Electric, Verimeter, and Accuderm models. The contractor shall provide one gauge with instructions, in "as new" condition, to be operated under the observation of the Engineer. Operation and calibration shall be in accordance with manufacturer's instructions.

555.25
(Reserved)

MEASUREMENT

555.26
Method

The method of measurement, as described in Section 106 will be DESIGNATED in the SCHEDULE OF ITEMS.

Components fabricated from metals listed in (a) below, such as castings, alloy steels, steel plates, anchor bolts and nuts, shoes, rockers, rollers, pins and nuts, expansion dams, roadway drains and scuppers, weld metal, bolts embedded in concrete, cradles and brackets, posts, conduits and ducts, and structural shapes for expansion joints and pier protection, will be considered as structural steel.

Unless otherwise provided, the weight of metal will be computed and based upon the following weights:

(a) Unit Weights, Pounds Per Cubic Foot

Aluminum, cast or rolled	173.0
Bronze or copper alloy	536.0
Copper sheet	558.0
Iron, cast	445.0
Iron, malleable	470.0
Lead, sheet	707.0
Steel, cast or rolled, including alloy, copper bearing, and stainless	490.0
Zinc	450.0

(b) Shapes, Plates, Railing, and Flooring. The weights of steel shapes and plates will be computed on the basis of their nominal weights and dimensions as SHOWN ON THE APPROVED SHOP DRAWINGS, without deducting for copes, cuts, and open holes. The weights of all plates shall be computed on the basis of nominal dimensions with no additions for overrun.

The weight of railing will be included as structural steel unless the SCHEDULE OF ITEMS contains a separate item for bridge railing under Section 556. The weight of steel grid flooring will be computed separately.

(c) Castings. The weight of castings will be computed from the dimensions SHOWN ON THE APPROVED SHOP DRAWINGS, deducting for open holes. To this weight will be added a 5-percent allowable for fillets and overruns.

Scale weights may be substituted for computed weights in the case of castings of small, complex parts for which accurate computations of weight would be difficult.

(d) Miscellaneous. The weight of the following will be excluded:

(1) Erection bolts placed for the convenience of the contractor.

(2) Shop and field paint.

(3) Galvanizing.

(4) Boxes, crates, and other containers used for shipping, together with sills, struts, and rods used for supporting members during transportation.

(5) High-strength steel bolts, nuts, and washers.

(6) Welds (shop and field).

PAYMENT

555.27 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

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.27

Pay Item		Pay Unit
555(01)	Structural Steel, Furnished, Fabricated, and Erected	LBS.
555(02)	Structural Steel, ____________________ Furnished, Fabricated, and Erected	LBS.
555(03)	Structural Steel, Furnished and Fabricated . . .	LBS.
555(04)	Structural Steel, ____________________ Furnished and Fabricated	LBS.
555(05)	Structural Steel, Erected	LBS.
555(06)	Structural Steel, ____________________ Erected.	LBS.
555(07)	Structural Steel, Furnished, Fabricated and Erected	L.S.

Section 556 - Bridge Railing

DESCRIPTION

556.01
Work

This work shall consist of furnishing and installing bridge railing and bridge approach railing.

556.02
Classification

Bridge railings will be classified as Concrete Bridge Railing, Steel Bridge Railing, Steel Bridge Approach Railing, Aluminum Bridge Railing, or Timber Bridge Railing in accordance with the predominate material contained in each.

MATERIALS

556.03
Requirements

Materials shall meet the requirements of the following Subsections:

Concrete	552.03-04
Joint Fillers	705.01
Paint	708.03
Reinforcing Steel	709.01
Beam-Type Steel Railing	710.04 (606.02)
Timber	710.05 (557.02)
Structural Steel	717.01
Hardware, Nuts, and Bolts	717.02-03
Aluminum Alloy	717.15
Aluminum Bolts and Nuts	717.16
Aluminum Welding Wire	717.17

CONSTRUCTION

556.04
Performance

Four sets of shop drawings or two sets and one reproducible set of same for steel or aluminum bridge railing, except beam-type steel railing, shall be submitted to the Engineer for review a minimum of 2 weeks prior to fabrication, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. Inspection of the railing will be made after installation.

The railing shall be constructed so as not to reflect any uneveness in the structure or approach fills. Unless otherwise specified, all railing posts shall be vertical. Railing shall not be placed on a span until centering or falsework has been removed, rendering the span self-supporting.

556.05
Concrete Railing

All concrete shall be Class A and all concrete construction shall meet the requirements of Section 552.

556.06
Steel Railing

Erection of steel railing shall meet the applicable requirements of Sections 555 and 606.

556.07
Aluminum Railing

The fabrication and erection of aluminum railing shall meet the requirements of Section 555 subject to the following amendments and additions:

(a) Cutting. Material 1/2 inch thick or less may be cut by shearing, sawing, or milling. Material over 1/2 inch thick shall be sawed or milled.

Cut edges shall be true, smooth, and free from burns or ragged breaks. Reentrant cuts shall be filleted by drilling prior to cutting.

Flame cutting will not be permitted.

(b) Bending. Material may be heated to a temperature not exceeding 400 °F for a period not exceeding 30 minutes to facilitate bending, unless cold bending is required to retain the original mechanical properties of the material furnished.

(c) Bolt Holes. Bolt holes shall be drilled to finished size or subpunched smaller than the nominal diameter of the fastener and reamed to size. The amount by which the diameter of a subpunched hole is smaller than that of the finished hole shall be at least one-quarter the thickness of the piece. The finished diameter of holes shall be not more than 7 percent greater than the nominal diameter of the fastener except:

(1) Slotted bolt holes, to take care of expansion, shall be provided as SHOWN ON THE DRAWINGS.

(2) Anchor bolt holes may be up to 25 percent greater than the nominal bolt diameter with a maximum of 1/2 inch greater than the nominal bolt diameter, unless otherwise SHOWN ON THE DRAWINGS.

(d) Contact with Other Materials. Where aluminum alloys come in contact with other metals, the contacting surfaces shall be thoroughly coated with an aluminum-impregnated calking compound approved by the Engineer, or a synthetic rubber gasket meeting the requirements of the SPECIAL PROJECT SPECIFICATIONS may be placed between the two surfaces. Aluminum alloys shall not be placed between the two surfaces and shall not be placed in contact with copper, copper-base alloys, lead, or nickel.

Where aluminum alloys come in contact with concrete or stone, the contact surfaces shall be thoroughly coated with an aluminum-impregnated calking compound approved by the Engineer. When a bond between aluminum and concrete is desired, the aluminum shall be coated with zinc-chromate paint and allowed to dry before installation.

Where aluminum alloys come in contact with wood, the contacting aluminum surface shall be coated with an approved aluminum calking compound.

556.08
Timber Railing

Erection of timber railing shall meet the requirements of Section 557. Erection of the posts for bridge approach railing shall meet the applicable requirements of Section 606.

556.09
Painting

All steel railing, except beam-type railing, shall be cleaned and given one primer coat and two field coats of paint meeting the requirements of Subsections 555.22 and 555.24 when SHOWN ON THE DRAWINGS. Beam-type railing shall be painted to meet the requirements of Section 606. If galvanizing is SHOWN ON THE DRAWINGS instead of painting, the requirements of AASHTO M 111, ASTM A 123, or AASHTO M 180, as applicable, shall apply.

MEASUREMENT

556.10
Method

The method of measurement as described in Section 106 will be DESIGNATED in the SCHEDULE OF ITEMS.

The length of railing will be along the line and grade of the railing from end to end of the rail except when terminal sections are in the SCHEDULE OF ITEMS.

The following incidental items will be included in payment for railing, and separate measurement and payment will not be made:

(a) Fastenings, anchors, and posts.

(b) Sheets, pads, shims, plates, etc.

(c) Reinforcing steel and portions of reinforcing steel extending into curbs and parapets.

(d) Approach railing, end anchorages, and terminal sections unless separate pay items are included in the SCHEDULE OF ITEMS for approach railing, end anchorages, or terminal section.

PAYMENT

556.11 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
556(01)	Concrete Bridge Railing	L.F.
556(02)	Steel Bridge Railing	L.F.
556(03)	Aluminum Alloy Bridge Railing	L.F.
556(04)	Timber Bridge Railing	L.F.
556(05)	Bridge Railing	L.S.
556(06)	Bridge Approach Railing	L.F.
556(07)	End Anchorage	EA.
556(08)	Terminal Section, Class ________________	EA.

Section 557 - Timber Structures

DESCRIPTION

557.01
Work

This work shall consist of construction of timber structures and timber portions of composite structures. It shall include furnishing and installing or installing only, all hardware, lumber, and timbers SHOWN ON THE DRAWINGS.

MATERIALS

557.02
Requirements

Materials shall meet the requirements of the following Subsections:

Structural Timber and Lumber	716.01
Hardware and Structural Steel	716.02
Preservative Treatments	716.03
Structural Glued Laminated Timber	716.04

Paint for timber structures shall be white and shall meet the requirements of AASHTO M 70, Type I, Class A. The paint, as specified, is intended for use in covering previously painted surfaces. When applied to unpainted timber, turpentine and linseed oil shall be added as required by the character of the surface in an amount not to exceed 1 pint each per gallon of the paint.

The contractor shall furnish the following compliance certificates to the Engineer upon delivery of the materials to the jobsite:

(a) Verification of compliance with grading rules and species of timber and lumber. Certification shall be by an agency accepted as competent by the American Lumber Standards Committee.

(b) Certification of preservative, penetration in inches, and retention in pounds per cubic foot (assay method) either by a qualified inspection and testing agency or by supplier certification if each piece is stamped or branded with the AWPB quality mark.

(c) Certification from a qualified inspection and testing agency indicating all glue-laminated members are in accordance with U.S. Department of Commerce Voluntary Standard PS 56, "Structural Glued Laminated Timber" (AITC A190) modified as SHOWN ON THE DRAWINGS.

(d) Such other certifications as SHOWN ON THE DRAWINGS or called for in the SPECIAL PROJECT SPECIFICATIONS.

CONSTRUCTION

557.03
Performance

Excavation, foundation, backfill, and embankments shall be in accordance with Section 206.

557.04
Storage & Handling of Material

All materials shall be so handled, stacked, and protected as to prevent scarring, breaking, warping, or weathering. Corners of heavy construction timbers and banded packages of lighter construction timber shall be protected when handled by slings.

All field cuts or abrasions made in fabricated timber after treatment shall be carefully trimmed and given three brush coats of the same type of preservative used in the original treatment unless otherwise SHOWN ON THE DRAWINGS. Field cuts shall be limited to holes and minor trimming, and cuts SHOWN ON THE DRAWINGS.

In addition to the requirement for field treatment, all field cut end grain of main stringers or timber members to be buried under ground shall be coated with an asphalt, coal tar, or creosote water proofing material meeting the requirements of AASHTO M115, 116, 118, or 121.

557.05 Workmanship

All lumber and construction timber shall be cut and framed so all joints will have even bearing over the entire contact surface. No shimming shall be done in making joints, and all joints shall be closed. Nails and spikes shall be driven to set the heads flush with the wood surface. All holes for smooth dowels, except for the dowels used to join glue-laminated deck panels, and drift pins shall be 1/16 inch less in diameter than the dowels or pins. Holes for bolts shall be bored with a bit of the same diameter as that of the bolt, except when galvanized hardware is specified, then all holes shall be drilled 1/16 inch greater than the bolt size. Holes for lag screws shall have the same diameter and depth as the shank of the screw, plus a lead hole for the threaded portion with the diameter approximately 75 percent of the shank diameter. Before driving bolts or pins, all holes bored after treatment shall be treated as specified in Subsection 557.04. Any holes drilled but not used after being treated shall be plugged with treated plugs.

557.06 Bolts & Washers

Washers of the size and type SHOWN ON THE DRAWINGS shall be placed under all bolt heads and nuts. All nuts shall be finally tightened to provide proper bearing and excess bolt lengths of more than 1 inch shall be cut off. After being finally tightened, all nuts shall be checked or burred effectively with a pointing tool to prevent loosening.

557.07 Framed Bents

Mud sills shall be firmly and evenly bedded to solid bearing and carefully tamped in place. Concrete pedestals for the support of framed bents shall be finished carefully so that sills or posts will bear evenly and uniformly over the entire bearing surface.

557.08 Pile Bents

Treatment, furnishing, and driving of construction piles shall be in accordance with Section 551.

557.09 Caps for All Bents

Timber caps shall be placed to obtain even and uniform bearing over the tops of all supporting construction posts or construction piles. Ends of caps shall be in true alinement.

557 .05

557.10 Bracing

Bracing shall be bolted through at intersections with the construction piling and construction posts and shall be capped or sealed as SHOWN ON THE DRAWINGS.

557.11 Solid-Sawn Stringers

Stringers shall be size matched at bearings and shall be positioned so that the camber is up and if possible so that knots near the edge will be in the top portion of the stringers. Bridging between stringers shall be neatly and accurately framed and securely fastened.

557.12 Glue-Laminated Panel Decks

Panels shall not be dragged or skidded. When lifted, they shall be supported in the weak-moment plane at a sufficient number of points to avoid overstressing, and the edges shall be protected from damage.

When dowels are SHOWN ON THE DRAWINGS between deck panels, a template or drilling jig shall be used to ensure that dowel holes are accurately spaced. The holes shall be drilled to a depth 1/4 inch greater than one-half the dowel length and of the same diameter as the dowel unless otherwise SHOWN ON THE DRAWINGS. A temporary dowel shall be used as a check for snug fit prior to production drilling. The dowels shall be of the size SHOWN ON THE DRAWINGS with the tips slightly tapered or rounded. A lubricant may be used to facilitate the connection process.

The tips of all dowels shall be partially and equally started into the holes of the two panels being joined. The panels shall be drawn together keeping the edges parallel, until the panels abut tightly. Each panel shall be securely fastened to each stringer as SHOWN ON THE DRAWINGS.

MEASUREMENT

557.13 Method The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS. Lumber and timber used for falsework, bracing, or sheeting will not be included. Furnishing and installation of piling and guardrail will be in accordance with Sections 551 and 556, respectively. Structure excavation will be in accordance with Section 206.

PAYMENT

557.14 Basis The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
557(01)	Treated Timber Structure	L.S.
577(02)	Treated Timber for Structure	MFBM

Section 558 - Prefabricated Bridge Structures

DESCRIPTION

558.01
Work

This work shall consist of furnishing and erecting the prefabricated superstructure portions of bridges and/or the erecting of Government-furnished prefabricated superstructure units. The length and width of the structure, including curbs and railings and the horizontal and vertical alignment will be as SHOWN ON THE DRAWINGS.

This work shall also include construction of bearing caps, bulkhead walls, and other supports, including excavation and backfill, when SHOWN ON THE DRAWINGS or on approved manufacturers' drawings. Unless furnished by the Government, prefabricated bridge units shall be furnished complete, in place, including deck, and railing when required, and all incidental materials connected therewith.

When there are specified limitations on acceptable girder, deck, and railing materials and type, they shall be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

MATERIALS

558.02
Requirements

Materials shall meet the requirements of the following Subsections:

Concrete	552.03-04
Prestressed Concrete	553.04-05
Precast Concrete	553A.02
Structural Steel Components	555.02
Railing	556.03
Timber and Hardware	557.02
Reinforcing Steel	709.01

Concrete compressive strength, structural steel ultimate strength and designation, timber species, grade, and treatment, and other material specifications shall be designated on the manufacturer's drawings and will be subject to approval by the Engineer prior to fabrication.

558.03
Design Requirements

Prefabricated bridges shall be designed in accordance with the AASHTO Standard Specifications for Highway Bridges, latest edition and addendums, for the HS20-44 loading, including impact, unless otherwise SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

558.04
Design Drawings & Calculations

The contractor shall submit to the Engineer for approval four copies of the design drawings, calculations, and shop drawings. They shall include any manufacturer's installation special handling specifications. The drawings shall be certified and bear the stamp of a registered professional engineer. Drawings shall be submitted sufficiently in advance of the start of the work to allow time for review by the Engineer and correction of any changes by the contractor. Such time shall be proportional to the complexity of the work, but not less than 21 days.

When Government-furnished units are specified, erection drawings and manufacturer's handling specifications will be furnished to the contractor by the Government.

CONSTRUCTION

558.05
Performance

The work shall conform to the applicable construction provisions of the following Subsections:

Concrete Structures	552.05-14
Prestressed Concrete Structures	553.06-16
Precast Concrete Structures	553A.03-04

Steel Structures	555.03-25
Timber Structures	557.03-12
Structure Excavation and Backfill	206.02-07
Reinforcing Steel	554.03-06
Bridge Railing	556.04-09

558.06 Government-Furnished Bridges

When Government-furnished prefabricated bridge units are specified, the contractor shall transport the units from the storage site designated in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS to the bridge site, and shall erect the units complete in place, including connection of all girders, diaphragms, railings, and other elements.

Upon taking possession of the Government-furnished units at the storage site, the contractor shall assume all liability for damage from his operations, including handling, transporting, and erecting the units in place, until final acceptance of the project by the Contracting Officer.

558.07 Manufacturer's Requirements

The contractor shall furnish all tools, devices, special equipment, and incidentals, and comply with all manufacturer's erection requirements. This manufacturer's requirement also applies to the movement and erection of Government-furnished units.

MEASUREMENT

558.08 Method

The method of measurement, as described in Section 106, will be designated in the SCHEDULE OF ITEMS.

PAYMENT

558.09 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
558(01)	Prefabricated Bridge	EA.
558(02)	Install Government-furnished Prefabricated Bridge	EA.

Section 559 - Log Structures

DESCRIPTION

559.01 Work

This work shall consist of cutting, hauling, and installing the timber for constructing log bridges, including abutments, piers, and superstructure.

This work shall also include structure excavation and backfill for abutments and piers and furnishing and installing all hardware.

MATERIALS

559.02 Requirements

The Government will provide trees from which the contractor can cut the required logs. The Government will mark trees for cutting or identify the general area from which trees shall be cut at locations SHOWN ON THE DRAWINGS. Trees to be cut for stringers shall be approved by the Engineer. The contractor shall dispose of all debris resulting from this operation in accordance with Section 201.

559.03 Lumber

Lumber shall be in accordance with the species, grades, and dimensions SHOWN ON THE DRAWINGS.

559.04 Aggregate

Aggregate, when shown for decking/surfacing, shall meet the requirements SHOWN ON THE DRAWINGS.

559.05 Hardware

All hardware shall be of the sizes, shapes, types, and finishes for specific uses as SHOWN ON THE DRAWINGS.

559.06 Matting

Fabric mat as SHOWN ON THE DRAWINGS shall meet the requirements of Section 720.

CONSTRUCTION

559.07 Performance

Excavation, foundation, backfill, and embankment work shall be in accordance with Section 206.

Timber caps shall be placed to obtain even and uniform bearing over the tops of supporting posts or piles and with post and pile ends in true alignment. All caps shall be secured as SHOWN ON THE DRAWINGS.

Stringers shall be size matched at bearings and shall be placed in position so that the crown is up and, if possible, so that knots that may affect the strength of the member will be in the top portion of the stringer.

Stringers shall be cut to the exact length with a square cut. A sufficient depth of material shall be removed from the top surface of the stringer to provide a bearing area for the decking as SHOWN ON THE DRAWINGS. Hewing shall not exceed 3/4 inch depth at the small end of the log. Hewing of the top of the butt end shall not exceed 3 inches in depth for a distance not to exceed one-fourth span length.

Bottom surface of the small end of the logs shall be cut or hewed only to the depth necessary to achieve the required bearing area. Tip ends smaller than the largest tip shall be blocked or shimmed. Butt ends may be cut or dapped to the depth of the largest top end. The maximum slope of any tip shall be 1 to 10. Top and bottom cuts shall be parallel. Where shims or blocks are used under small ends, the shims should cover the entire bearing area.

All logs, including face logs, tie logs, mud sills, and anchor logs, shall be notched together as SHOWN ON THE DRAWINGS and shall be tied or drift pinned together.

All necessary clearing, grubbing, and excavation shall be completed and approved prior to starting the bridge erection. Wood chinking or rock may be hand placed for backing behind minor open spacing between logs, provided that their least dimension is greater than the minimum opening between logs. When rock is used, the larger rocks shall be placed against the logs and backed up with smaller rocks in such a manner that no materials can escape or be washed out.

MEASUREMENT

559.08 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Excavation and Backfill are included in the measurement for the item for Log Structure and no separate measurement and payment will be made.

PAYMENT

559.09 Basis

The accepted quantities will be paid for at the contract unit price for the pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item	Pay Unit
559(01) Log Structure	EA.

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SECTION 600 INCIDENTAL CONSTRUCTION

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Section 601 - Mobilization

DESCRIPTION

601.01 Work — This work shall consist of preparatory work and operations necessary for the movement of personnel, equipment, supplies, and incidentals to the project site, and for all other work and operations that must be performed or that cause costs to be incurred prior to beginning work on the various items on the project site.

MEASUREMENT

601.02 Method — The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

PAYMENT

601.03 Basis — Mobilization will be paid for at the contract unit price for the item as shown in the SCHEDULE OF ITEMS.

Progress payments will be made as follows:

(a) When 5 percent or more of the original contract amount is earned from other pay items, 50 percent of the amount for mobilization, or 5 percent of the original contract amount, whichever is less, will be paid.

(b) When 10 percent or more of the original contract amount is earned from other pay items, 100 percent of the amount for mobilization, or 10 percent of the original contract amount, whichever is less, will be paid.

(c) Upon completion of all work on the project, any unpaid amount for mobilization will be paid.

The total of all payments, including bonding, shall not exceed the original contract amount for this item.

Payment will be made under:

Pay Item		Pay Unit
601(01)	Mobilization	L.S.

Section 602 - Minor Concrete Structures

DESCRIPTION

602.01 Work

This work shall consist of constructing reinforced or unreinforced minor concrete structures.

MATERIALS

602.02 Requirements

Materials shall meet the requirements of the following Subsections:

Mortar	701.03
Portland Cement	701.01
Aggregate	703.01(c)
Reinforcing Steel	709.01
Curing Materials	711.01
Air-Entraining Admixtures	711.02
Water	712.01
Fly Ash	712.14

602.03 Concrete Composition

The concrete composition method shall be as shown in the SCHEDULE OF ITEMS.

Method A. A mix design showing the proposed weights of aggregate, water, and cement per cubic yard of concrete shall be furnished to the Engineer. Cement, aggregate, and water shall be proportioned to obtain concrete with good workability. Slump shall not be more than 4 inches as determined by AASHTO T 119. Air-entrainment shall be 5 percent plus or minus 1 percent as determined by AASHTO T 152 or T 196.

The concrete shall develop a 28-day minimum compressive strength of 3,000 psi unless otherwise SHOWN ON THE DRAWINGS. Concrete for specimens shall be furnished by the contractor at no cost to the Government. Strength will be determined by test cylinders made and cured in accordance with AASHTO T 23 and tested in accordance with AASHTO T 22.

Failure of any test cylinder for any structural element tested will be considered evidence of noncompliance with the strength requirement of this specification.

Method B. The contractor shall submit for approval the following information:

602
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(a) The type, grading, and sources of aggregate.

(b) Type and source of cement, blended cement, or fly ash.

(c) Proposed scale weights of each aggregate in pounds per cubic yard of concrete.

(d) Proposed quantity of water in pounds per cubic yard of concrete.

(e) Proposed quantity of cement in pounds per cubic yard of concrete.

(f) Admixtures.

(g) Air content.

(h) Slump.

(i) 28-day compressive strength.

The concrete shall contain not less than 5.5 sacks of cement per cubic yard. Slump shall not be more than 4 inches as determined by AASHTO T 119.

When a commercial supplier is used, the contractor shall furnish a certification with each truckload of concrete certifying that the material and mix proportions used are in conformance with the approved mixture.

Method C. The concrete shall be made using a dry, preproportioned, blended, and bagged mix meeting the requirements of ASTM C 387 and mixed at the jobsite in accordance with the manufacturer's recommendations.

Fly Ash or Pozzolan Modified Concrete - Fly ash, at the contractor's option, may be substituted for cement at the rate of 1.2 pounds of fly ash for 1.0 pounds of Portland cement. After substitution, design aggregate volumes shall be reduced by an amount equal to the net increase in volume of the combined cement and fly ash. Not less than 10 percent nor more than 20 percent of the weight of Portland cement required may be replaced with fly ash at the above rate. For purposes of controlling the maximum water/cement ratio of 0.49, the water/cement ratio for fly ash modified concrete shall be the ratio of the weight of water to the combined weights of Portland cement and 60 percent of the weight of the fly ash.

The standard 28-day curing period for compressive strength tests shall be extended for fly ash modified concrete by 1 day (rounded to the nearest whole day) for each 1.5 percent of Portland cement replaced with fly ash at the selected rate. (Example: If the maximum of 20 percent cement is replaced, the curing period for cylinders would be 41 days.)

CONSTRUCTION

602.04
Forms

Forms shall be designed and constructed so they can be removed without damaging the concrete. They shall be free of bulge and warp, and constructed so the finished concrete shall be of the form and dimensions SHOWN ON THE DRAWINGS and true to line and grade. Concrete may be placed without forms where SHOWN ON THE DRAWINGS.

Forms for concrete containing a retarding admixture, fly ash, or other pozzolan replacement for cement shall be designed to contain the lateral pressures exerted by the full anticipated height of fluidized concrete, unless documented information in regard to initial set is provided by the manufacturer.

602.05
Placing Concrete

All reinforcing steel shall be placed in position SHOWN ON THE DRAWINGS and securely held in place by approved supports during placing of concrete. Concrete shall not be placed until the grading, forms, and steel reinforcements have been inspected and approved by the Engineer. The contractor shall give the Engineer 24 hours notice prior to placement of any concrete.

Method A & B concrete shall be discharged into the forms within 1-1/2 hours after the introduction of the cement to the aggregate. Method C concrete shall be discharged into the forms within 1-1/2 hours after the introduction of water to the mixture. Retempering concrete shall not be permitted. The cement shall be added to the mixer at the jobsite whenever this condition cannot be met, or when required in the SPECIAL PROJECT SPECIFICATIONS. Concrete shall not be mixed or placed when the daily minimum atmospheric temperature is, or is expected to be, less than 40 °F unless adequate provisions are made to protect the concrete.

Concrete shall be placed to avoid segregation. High-frequency internal vibrators shall be used for consolidating concrete in the forms. Vibrators shall be operated to produce concrete free of voids, but shall not be held so long in one place as to result in segregation or formation of laitance on the surface.

Method C concrete shall be placed in forms and may be rodded instead of internally vibrated as necessary to remove voids.

The use of aluminum pipe, conduit, or troughs for transporting concrete will not be permitted. When concrete is pumped, sampling shall be from the discharge stream at the point of placement.

602.06
Finishing

(a) Formed Surfaces. Unless otherwise SHOWN ON THE DRAWINGS, all fins and irregular projections exceeding 1/4 inch shall be removed from the exposed surfaces. Holes produced by removal of form ties shall be filled with dry-pack mortar or other approved patching compounds.

(b) Unformed Surfaces. Unformed surfaces shall be struck off with a straight-edge and finished to a smooth uniform texture by floating and traveling. Final finish of the surface will be as SHOWN ON THE DRAWINGS.

602.07
Curing Concrete

Beginning immediately after finishing, all concrete shall be cured a minimum of 7 days or, if high early strength cement is used, a minimum of 3 days. For fly ash modified concrete placed in structures, the required moisture controlled curing period shall be:

Percentage of Cement Replaced by Weight	Required Curing Period
10%	9 days
11-15%	10 days
16-20%	11 days

For cold weather concreting, controlled temperature shall be maintained for the required curing period. The above requirement for an extended curing period may be waived if a compressive strength of 65 percent of the specified 28-day design strength is achieved in 6 days.

Curing shall be accomplished to maintain a minimum concrete temperature of 40 °F and to maintain concrete in a continuously moist condition. Concrete shall be maintained in a moist condition by supplying additional moisture or by preventing moisture loss.

602
.05

Acceptable methods of supplying additional moisture are by ponding or sprinkling, and covering with burlap cloth maintained in a saturated condition. Surfaces SHOWN ON THE DRAWINGS may be covered with saturated sand or 6 inches of saturated hay or straw to retain moisture.

Acceptable methods of preventing moisture loss are by applying liquid membrane-forming compounds, or waterproof paper or polyethylene sheet materials. Liquid membrane-forming compounds shall be applied by spraying at the coverage rates and patterns recommended by the manufacturer. Sheet materials shall have overlapped sealed joints and form a complete waterproof cover over the entire concrete surface.

602.08
Backfilling

Backfilling shall be in accordance with Subsection 206A.05.

602.09
(Reserved)

MEASUREMENT

602.10
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

PAYMENT

602.11 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
602(01)	Concrete Method A	C.Y.
602(02)	Concrete Method B	C.Y.
602(03)	Concrete Method C	L.S.

Section 603 - Metal Pipe

DESCRIPTION

603.01
Work

This work shall consist of furnishing and installing, or installing only, metal pipe and pipe appurtenances, including all bedding and backfilling required to complete the work. The term metal refers to aluminum, and steel.

MATERIALS

603.02
Requirements

Materials shall meet the requirements of the following Subsections:

Flexible Plastic Gaskets	705.09
Corrugated Steel Pipe and Pipe Arches.	707.01
Bituminous-Coated Corrugated Steel Pipe and Pipe Arches	707.02
Polymeric-Precoated Steel Pipe, Pipe Arches, and Underdrains	707.03
Corrugated Aluminum Alloy Culvert Pipe	707.06
Bituminous-Coated Corrugated Aluminum Alloy Culvert Pipe	707.08
Rubber Gaskets	705.03
Aluminum-Coated Type 2 Corrugated Steel Pipe and Pipe Arches	707.13
Aluminum-Zinc Coated Corrugated Steel Pipe and Pipe Arches	707.14
Bituminous-Coated Polymeric-Precoated Steel Pipe, Pipe Arches and Underdrains	707.15

Bedding material shall meet the requirements of Subsection 603.04.

Backfill materials shall meet the requirements of Subsection 603.08.

Damaged spelter coating caused by welding, field cutting, or mishandling shall be cleaned and painted as specified in AASHTO M 36.

End sections shall be constructed of a material meeting the requirements of AASHTO M 218 or AASHTO M 36.

Bituminous-coated end sections shall be coated to meet the requirements of AASHTO M 243 or AASHTO M 190.

The materials used in each pipe installation shall be compatible with each other to prevent electrolysis or physical failure.

Either annular or helical pipe corrugations will be acceptable; and helical corrugated pipe containing annular rerolled ends may be used in conjunction with annular pipe of like or compatible materials.

A fabricators Certification shall be furnished certifying that the sheet and pipe fabrication are in accordance with AASHTO M 36, M 196, and M 245 as applicable. The Certification shall be submitted prior to installation of the pipe.

The lengths and locations of individual pipe SHOWN ON THE DRAWINGS are approximate. Pipe shall not be ordered until culvert locations are DESIGNATED ON THE GROUND and a written list of the correct lengths is issued by the Engineer.

CONSTRUCTION

603.03
Excavation

Excavation shall be in accordance with the requirements of Section 206A.

Pipe that is installed in or that will affect streams SHOWN ON THE DRAWINGS as important fisheries shall be installed only during those periods SHOWN ON THE DRAWINGS.

603.04
Bedding

Bedding shall consist of bedding the pipe to a depth of not less than 10 percent of its total height. The foundation surface, after excavation in accordance with Subsection 206A.03 (b), shall be compacted in accordance with Subsection 603.08 and shaped to fit the pipe.

The bedding material shall be selected mineral soil meeting the requirements for backfill in Subsection 603.08. The completed bedding shall have a longitudinal camber when SHOWN ON THE DRAWINGS.

603.05
Laying Pipe

The lower segment of the pipe shall be in contact with the bedding for the required depth throughout its entire full length. Outside circumferential laps shall be placed facing upstream.

Paved or partially lined pipe shall be laid so the longitudinal centerline of the paved segment coincides with the flowline. Elliptical pipe shall be placed with the major axis within 5 degrees of a vertical plane through the longitudinal axis of the pipe.

The final installed alignment shall be such that no reverse grades exist and no point shall vary from a straight line drawn from inlet to outlet by more than 2 percent horizontally and vertically of the culvert length or 1 foot, whichever is less, unless otherwise SHOWN ON THE DRAWINGS.

No pipe shall be placed in service until a suitable outlet is provided.

Helically corrugated lock-seam pipe shall be installed with the seam at the inlet end placed below the horizontal centerline. This requirement applies to the outlet end when the outlet is less than 5 feet below subgrade.

Longitudinal laps on riveted or spot-welded pipe shall be positioned at any location between 45 degrees above or below horizontal.

603.06
Joining Pipes

Pipe shall be firmly joined by form-fitting coupling bands. End sections shall be attached to pipe by connecting bands or other means as recommended by the manufacturer. Gaskets shall be installed at each joint to form a watertight connection when SHOWN ON THE DRAWINGS. Dimpled bands shall not be used when the slope of the pipe is greater than 15 percent.

The coupling bands shall meet the strength requirements of field joints for Non-Erodible Soil Condition--Special Joint Type according to Division II, Section 23 of the "Standard Specifications for Highway Bridges" by AASHTO.

603.07
Shop Elongation

When SHOWN ON THE DRAWINGS, the vertical diameter of round pipe shall be increased 5 percent by shop elongation.

603.08
Backfilling

Pipe meeting any of the following conditions shall not be placed or backfilled until the excavation and foundation have been approved by the Engineer:

(a) Embankment height greater than 10 feet at subgrade centerline.

(b) Installation in a live stream.

(c) Round pipe with a diameter of 48 inches or greater.

(d) Pipe arches with a span of 50 inches or greater.

After the bedding is prepared and the pipe is placed, selected material shall be placed in layers not exceeding 6 inches loose thickness and compacted under the haunches and alongside the pipe. The material shall be readily compactible material free of frozen lumps, chunks of highly plastic clay (Plasticity Index greater than 10), or other objectionable material. Rocks larger than 3 inches in greatest dimension shall not be used within 1 foot of the pipe. On each side of the pipe there shall be an area of compacted material at least as wide as one diameter of the pipe. Backfill shall be compacted without damaging or displacing the pipe. The density shall be Method A or B as shown in the SCHEDULE OF ITEMS.

Method A. Backfill density shall exceed the density of the surrounding embankment.

Method B. Backfill density shall exceed 95 percent of the maximum density as determined by AASHTO T 99-Method C or D.

Backfilling and compacting shall be continued until the backfill is a minimum of 12 inches above the top of the culvert.

After being bedded and backfilled, pipe shall be protected by an adequate cover of embankment before heavy equipment is permitted to cross during roadway construction.

Pipe distorted more than 5 percent of nominal dimensions, ruptured, or broken shall be replaced.

603.09
(Reserved)

MEASUREMENT

603.10
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

When shown in the SCHEDULE OF ITEMS, backfill material adjacent to the pipe will be measured 1 foot horizontally and vertically from the outside dimensions of the pipe with a deduction for the volume of the pipe along the full length of the backfill.

PAYMENT

603.11
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will made under:

Pay Item		Pay Unit
603(01)	____-Inch Corrugated Metal Pipe, ____-Inch Thickness for Steel or ____-Inch Thickness for Aluminum, Method ____	L.F.
603(02)	____-Inch Span, ____-Inch Rise, Corrugated Metal Pipe Arch, ____ -Inch Thickness for Steel, or ____-Inch Thickness for Aluminum, Method____	L.F.
603(03)	____-Inch Metal End Section	EA.
603(04)	____-Inch Span, ____-Inch Rise Metal End Section	EA.
603(05)	____-Inch Corrugated Steel Pipe, ____-Inch Thickness, Method ____	L.F.
603(06)	____-Inch Span, ____ -Inch Rise, Corrugated Steel Pipe Arch, ____ -Inch Thickness, Method ____	L.F.

603(07)	____-Inch Steel End Section	EA.
603(08)	____-Inch Span, ____-Inch Rise Steel End Section	EA.
603(09)	____-Inch ____ Type ____ Coated Corrugated Steel Pipe, ____-Inch Thickness, Method____	L.F.
603(10)	____-Inch, ____ Type ____ Coated Paved Invert, Corrugated Steel Pipe, ____ -Inch Thickness, Method ____	L.F.
603(11)	____-Inch Span, ____-Inch Rise, ____ Type ____ Coated Corrugated Steel Pipe Arch, ____-Inch Thickness, Method ____	L.F.
603(12)	____-Inch ____ Type ____ Coated Steel End Section	EA.
603(13)	____-Inch Span, ____ -Inch Rise, ____Coated Steel End Section	EA.
603(14)	____-Inch Corrugated Aluminum Pipe, ____-Inch Thickness, Method ____	L.F.
603(15)	____-Inch Paved Invert Corrugated Aluminum Pipe, ____-Inch Thickness, Method ____	L.F.
603(16)	____-Inch Span, ____-Inch Rise, Corrugated Aluminum Pipe Arch, ____-Inch Thickness, Method ____	L.F.
603(17)	____-Inch Aluminum End Section	EA.
603(18)	____-Inch Span, ____-Inch Rise Aluminum End Section	EA.
603(19)	Pipe Elbow, ____-Inch Diameter, ____-Inch Thickness	EA.
603(20)	Branch Connection, ____-Inch Diameter, ____-Inch Thickness	EA.
603(21)	Furnishing and Placing Backfill Material for Pipe	C.Y.

When materials are furnished by the Forest Service, the note "Government-furnished materials" will be added to the description of the pay item.

Section 606 - Guardrail

DESCRIPTION

606.01
Work

This work shall consist of furnishing and installing guardrail.

MATERIALS

606.02
Requirements

Materials shall meet the requirements of the following Subsections:

Wire Rope or Wire Cable	709.02
Chain Link Fabric	710.03
Metal Beam Rail	710.04
Timber Rail	710.05
Guardrail Posts	710.07
Guardrail Hardware	710.08
Box Beam Rail	710.09
Concrete	602.03

High-strength, unpainted, ungalvanized, weathering steel shall meet the following requirements:

(a) AASHTO M 180 Type 4.

(b) Two to six times the resistance to atmospheric corrosion of carbon steel and able to develop a tightly adherent, impervious, oxide coating as the steel weathers.

High tensile strength bolts for weathering-steel guardrail shall meet the mechanical properties of AASHTO M 164, Type 3.

CONSTRUCTION

606.03
Posts

Posts shall be plumb. Posts shall not be battered or distorted when driven. Post holes shall be backfilled with acceptable material placed in layers of not more than 4 inches loose thickness and thoroughly compacted. When it is necessary to cut post holes in existing pavement, all loose material shall be removed and the pavement replaced in kind.

606.04
Rail Elements

The class and type of rail elements shall be as SHOWN ON THE DRAWINGS. The installation shall be smooth and continuous with laps in the direction of traffic flow. All bolts, except adjustment bolts, shall be drawn tight. Bolts shall be of sufficient length to extend beyond the nuts by not more than 1 inch. Rails shall be shop bent for curves with 150-foot radius or less.

Galvanized surfaces that have been abraded to expose the base metal, threaded portions of all fittings and fasteners, and cut ends of bolts shall be cleaned and coated with a commercially available, zinc-rich paint (pure zinc in vehicle).

When concrete anchors are poured in place, the anchors shall not be connected to the guardrail until 7 days after the concrete has been placed. Concrete shall meet the requirements of Section 602, Method A or B as SHOWN ON THE DRAWINGS.

MEASUREMENT

606.05
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

The length of guardrail will be from end to end of the rail except where end connections are made to concrete or steel structures, in which case the length will be to the face of these structures. Double-faced rail attached to the same post will be measured as a single unit.

The quantity of end anchorages and terminal sections will be the number of units of each kind specified and installed. Guardrail length will not include end anchorage or terminal sections.

PAYMENT

606.06 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment shall be made under:

Pay Item		Pay Unit
606(01)	Rustic Guardrail	L.F.
606(02)	Untreated Wood Guardrail	L.F.
606(03)	Preservative-Treated Wood Guardrail	L.F.
606(04)	Box Beam-Type Guardrail, Class ____________ . . .	L.F.
606(05)	Galvanized ________, Beam-Type Guardrail, Class ________, Type _______.	L.F.
606(06)	High-Strength Weathering Beam-Type Guardrail, Class _______,Type ______	L.F.
606(07)	End Anchorage, Type ________	EA.
606(08)	Terminal Section, Type _________	EA.

Section 611 - Development of Pits & Quarries

DESCRIPTION

611.01
Work

This work shall consist of clearing, grubbing, topsoil stripping, removal of overburden, access road development, restoration, and other incidental work required for pit or quarry development.

CONSTRUCTION

611.02
General

All work shall be performed in accordance with Sections 201, 203, 625, landscape preservation requirements, and the pit and quarry development and/or restoration plan as SHOWN ON THE DRAWINGS.

611.03
Source

Designation of sources will be in accordance with requirements SHOWN ON THE DRAWINGS or specified in the SPECIAL PROJECT SPECIFICATIONS.

611.04
Clearing, Grubbing & Slash Cleanup

Clearing, grubbing, and slash cleanup requirements shall be in accordance with Section 201 and as SHOWN ON THE DRAWINGS.

611.05
Access Roads

Access roads to the pit or quarry shall be constructed or reconditioned in accordance with Section 203 or 306 and as SHOWN ON THE DRAWINGS.

611.06
Topsoil

Stripping, stockpiling, and placing of topsoil obtained from the site shall be in accordance with Section 203 and as SHOWN ON THE DRAWINGS.

611.07
Overburden

Removal of overburden to expose rock material for aggregate production and the stockpiling or placement of overburden in embankment within the limits of the pit or quarry shall be in accordance with Section 203 and as SHOWN ON THE DRAWINGS.

611.08
Ground Control & Haulways

The work shall be in accordance with MSHA 30 CFR-Part 56 that relate to ground control and haulways. Any deterioration of overburden slopes, safety benches, protective berms, or encroachment on clearing limits shall be immediately corrected.

611.09
Oversize Material

All material suitable for aggregate, developed in stripping, overburden removal, and excavation of rock material, regardless of size, shall be utilized for aggregate unless other disposition is SHOWN ON THE DRAWINGS.

611
.01

611.10
Restoration

After excavation has been completed in a part or all of the area, the sides shall be sloped and graded and the general pit area smoothed as SHOWN ON THE DRAWINGS. Oversize material, if left in the pit or quarry, shall be evenly distributed and overburden material spread over the bottom of the pit prior to spreading topsoil.

Access roads SHOWN ON THE DRAWINGS for obliteration shall be ripped, drained, blocked to traffic, and seeded in accordance with Section 625.

MEASUREMENT

611.11
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

PAYMENT

611.12
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
611(01)	Pit Development	EA.
611(02)	Quarry Development	EA.

611
.12

Section 616 - Waterstops

DESCRIPTION

616.01
Work

This work shall consist of constructing waterstops formed of rubber or plastic in expansion and construction joints.

MATERIALS

616.02
Requirements

Materials shall meet the requirements of the following Subsections:

Rubber Waterstops	705.07
Plastic Waterstops	705.08

CONSTRUCTION

616.03
Performance

The size, type, and locations of waterstops shall be as SHOWN ON THE DRAWINGS.

616.04
(Reserved)

616.05
Rubber Waterstops

Splices shall be made watertight in accordance with the manufacturer's instructions. If splices are used, the contractor shall make at least one preliminary field splice sample for testing by the Engineer. No splicing shall be done until tests indicate a tensile strength of at least 50 percent of the tensile strength of the unspliced rubber waterstops.

616.06
Plastic Waterstops

Splices shall be made water-tight without damage to the plastic, in accordance with the manufacturer's instructions. Preliminary splice samples shall be made and tested in accordance with Subsection 616.05 and no splices shall be made in the work until a tensile strength for splices of at least 80 percent of the unspliced plastic waterstops is indicated by tests.

616.07
Placing Waterstops

Waterstops shall be placed at the locations SHOWN ON THE DRAWINGS. Waterstops shall not be displaced or damaged. All surfaces of the waterstops shall be kept free of oil, grease, dried mortar, or any other foreign matter while the waterstops are being embedded in concrete. All portions of the waterstops designed for embedment shall be tightly enclosed by concrete.

MEASUREMENT

616.08
Method

The method of measurement, as described in Section 106, will be designated in the SCHEDULE OF ITEMS.

PAYMENT

616.09
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
616(01)	Rubber Waterstop	S.F.
616(02)	Rubber Waterstop ________ Width	L.F.
616(03)	Rubber Waterstop	L.S.
616(04)	Plastic Waterstop	S.F.
616(05)	Plastic Waterstop ________ Width	L.F.
616(06)	Plastic Waterstop	L.S.

Section 617 - Structural-Plate Pipe, Pipe Arches, & Arches

DESCRIPTION

617.01
Work

This work shall consist of furnishing and installing, or installing only structural-plate pipe, or pipe arches, and arches.

This work shall also include joints and connections to pipes, catch basins, headwalls, and other appurtenances required to complete the structure.

MATERIALS

617.02
Requirements

Materials shall meet the requirements of the following Subsections:

Grout	701.02
Structural Steel Plate for Pipe, Pipe Arch, and Arches. .	707.10
Full Bituminous-Coated Structural-Plate Pipe, ... Pipe Arch and Arches	707.11
Aluminum Alloy Structural Plate for Pipe, Pipe Arch, and Arches	707.12

CONSTRUCTION

617.03
Excavation,
Bedding, & Backfill

Excavation shall be in accordance with the requirements of Section 206A.

Pipe that is installed in or that will affect streams SHOWN ON THE DRAWINGS as important fisheries shall be installed only during those periods SHOWN ON THE DRAWINGS.

Bedding shall consist of bedding the pipe to a depth of not less than 10 percent of its total height. The foundation surface shall be excavated in accordance with Subsection 206A.03(b).

The bedding material shall be selected mineral soil meeting the same requirements as backfill material.

Pipe shall not be placed or backfilled until the excavation and foundation have been approved by the Engineer.

After the bedding is prepared and the pipe is placed, selected material shall be placed in layers not exceeding 6 inches loose thickness and compacted under the haunches and alongside the pipe. The material shall be readily compactible material free of frozen lumps, chunks of highly plastic clay, or other objectionable material. Rocks larger than 3 inches in greatest dimension shall not be used within 1 foot of the pipe. On each side of the pipe there shall be an area of compacted material at least as wide as one diameter of the pipe or 12 feet, whichever is less. Backfill shall be compacted without damaging or displacing the pipe.

Backfill density shall exceed 95 percent of the maximum density as determined by AASHTO T 99, Method C or D.

Backfilling and compacting shall be continued until the backfill is 12 inches above the top of the pipe.

After being bedded and backfilled, pipe shall be protected by an adequate cover of embankment as indicated in applicable cover height tables before heavy equipment is permitted to cross during roadway construction.

Pipe distorted more than 5 percent of nominal dimensions, ruptured, or broken shall be replaced.

When filling around and over arches before headwalls are in place, the first embankment material shall be placed midway between the ends of the arch, forming as narrow a ramp as possible, until the top of the arch is reached. The ramp shall be built evenly from both sides, and the embankment material shall be compacted as it is placed. After the two ramps have been built to the top of the arch, the remainder of the embankment material shall be deposited from the top of the arch both ways from the center to the ends, and as evenly as possible on both sides of the arch.

If the headwalls are built before any embankment material is placed around and over the arch, the embankment material shall first be placed adjacent to one headwall until the top of the arch is reached, after which it shall be dumped from the top of the arch toward the other headwall, depositing the material evenly on both sides of the arch.

The procedures specified above shall be followed in multiple installations and the embankment material shall be brought up evenly on each side of each arch so that unequal pressure will be avoided.

617.04
Fabrication

Plates for structural plate pipe, arches, and pipe arches shall be fabricated in accordance with AASHTO M 167 or M 219.

Plates shall be formed to provide lap joints. The bolt holes shall be punched so that all plates having like dimensions, curvature, and the same number of bolts per foot of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross sectional dimensions of the finished structure will be as SHOWN ON THE DRAWINGS.

Plates for forming skewed or sloped ends shall be cut to give the angle of skew or slope SHOWN ON THE DRAWINGS. Legible identification numerals shall be placed on each plate to designate its proper position in the finished structure.

617.05
Footings for Arches

Footings for arches shall be constructed as SHOWN ON THE DRAWINGS.

617.06
Erection

Structural-plate pipe, arches, and pipe arches shall be erected in their final position by connecting the plates with bolts at longitudinal and circumferential seams. Drift pins may be used to facilitate matching of holes. All plates shall be placed in the order recommended by the manufacturer with joints staggered so that not more than three plates come together at any one point. All bolts shall be drawn tight, without overstressing, before beginning the backfill.

Steel bolts for structural-plate sections shall be torqued during installation to a minimum of 100 foot-pounds, and a maximum of 300 foot-pounds. The bolts for aluminum structural-plate sections shall be torqued during installation to a minimum of 100 foot-pounds, and a maximum of 200 foot-pounds.

Bolts shall be of sufficient length to completely engage the nut threads.

After steel pipe or arches have been erected, all damaged spelter shall be wire brushed and painted as specified in AASHTO M 167.

617.07
(Reserved)

MEASUREMENT

617.08
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

PAYMENT

617.09 Basis The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
617(01)	Steel Structural-Plate, Size __________, __________ Coated, __________ Thickness . . .	L.F.
617(02)	Aluminum Structural-Plate, Size __________, __________ Coated, __________ Thickness, . . .	L.F.
617(03)	Installation Only.	EA.

When materials are furnished by the Forest Service, the note "Government-furnished materials" will be added to the description of the pay item.

Section 617A - Structural-Plate Long-Span Structures

DESCRIPTION

617A.01
Work

This work shall consist of furnishing and installing, or installing only, structural-plate long-span structures including such shapes as horizontal elipse, low profile arch, and high profile arch. The work shall include the furnishing and placement of stiffening ribs or reinforced concrete thrust beams or other special structural features.

This work shall also include joints and connections to pipes, catch basins, headwalls, and other appurtenances required to complete the structure.

MATERIALS

617A.02
Requirements

Materials shall meet the requirements of the following Sections and Subsections:

Grout	701.02
Structural Steel Plate for Pipe, Pipe Arch, and Arches	707.10
Full Bituminous-Coated Structural-Plate Pipe, Pipe Arch and Arches	707.11
Aluminum Alloy Structrual Plate for Pipe, Pipe Arch and Arches	707.12
Reinforcing Steel	709

The thickness of the structural plate shall not be less than the plate thickness SHOWN ON THE DRAWINGS.

Concrete shall meet the requirements of Section 602, Method A or B as SHOWN ON THE DRAWINGS.

CONSTRUCTION

617A.03
Excavation,
Bedding, & Backfill

Excavation and backfilling shall be to the limits SHOWN ON THE DRAWINGS. Excavation shall be in accordance with the requirements of Section 206A.

Pipe that is installed in or that will affect streams SHOWN ON THE DRAWINGS as important fisheries shall be installed only during those periods SHOWN ON THE DRAWINGS.

Bedding shall consist of bedding the pipe to a depth of not less than 10 percent of its total height. The foundation surface shall be excavated in accordance with Subsection 206A.03(b).

The bedding material shall be selected mineral soil meeting the same requirements as backfill material.

Pipe shall not be placed or backfilled until the excavation and foundation have been approved by the Engineer.

After the bedding is prepared and the pipe is placed, selected material shall be placed in layers not exceeding 6 inches loose thickness and compacted under the haunches and alongside the pipe. The material shall be readily compactible material free of frozen lumps, chunks of highly plastic clay (Plasticity Index greater than 10), or other objectionable material. Rocks larger than 3 inches in greatest dimension shall not be used within 1 foot of the pipe. On each side of the pipe there shall be an area of compacted material at least as wide as one diameter or span of the structure or 12 feet, whichever is less. Backfill shall be compacted without damaging or displacing the pipe.

Backfill density shall exceed 95 percent of the maximum density as determined by AASHTO T 99, Method C or D.

Backfilling and compacting shall be continued until the backfill is 12 inches minimum above the top of the pipe.

After being bedded and backfilled, pipe shall be protected by an adequate cover of embankment before heavy equipment is permitted to cross during roadway construction.

Pipe distorted more than 5 percent of nominal dimensions, ruptured, or broken shall be replaced.

Prior to construction, a meeting shall be held at a time and place agreed to by the Engineer to discuss construction procedures. The meeting shall include the contractor, any involved subcontractor, and a qualified representative of the manufacturer of the arch structure.

Before backfilling, the erected structure shall meet the design shape within tolerances permitted by the manufacturer. If the structure is not within the allowable tolerances, suitable temporary supports shall be required to bring it into the proper shape.

The contractor shall monitor and record the horizontal and vertical displacement of the structure periodically during placement of backfill and embankment. These records shall be made available upon request to the Engineer. Displacements shall be measured to the nearest 1/8 inch at locations and frequencies established by the manufacturer's representative to ensure that the rate of change will not produce ultimate displacement beyond allowable tolerances. Structural backfill shall extend a minimum of 6 feet behind each thrust beam. Wheel or track machines shall be kept a safe distance away from the arch. If the rate of shape change for the structure exceeds the manufacturer's recommendation during backfill, backfill methods or materials, or both, shall be modified to keep structure shape within the manufacturer's tolerance.

A manufacturer's representative shall be on the site during all backfilling operations.

617A.04 Design & Fabrication

Four sets of shop drawings of the plate structure shall be submitted to the Engineer a minimum of 21 days in advance of planned construction. Shop drawings shall be accompanied by all calculations used to determine the size, shape, location, and spacing of stiffening ribs, thrust beams, or other special structural features.

Plates shall be fabricated in accordance with AASHTO M 167 or M 219.

Plates shall be formed to provide lap joints. The bolt holes shall be punched so that all plates having like dimensions, curvature, and the same number of bolts per foot of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross sectional dimensions of the finished structure will be as SHOWN ON THE DRAWINGS.

Plates for forming skewed or sloped ends shall be cut to give the angle of skew or slope SHOWN ON THE DRAWINGS. Legible identification numerals shall be placed on each plate to designate its proper position in the finished structure.

617A.05 Footings, Headwalls, & Collars

Footings, headwalls, collars and other associated concrete work shall be constructed as SHOWN ON THE DRAWINGS. Concrete work and placement of reinforcing steel shall be in accordance with Section 602.

617A.06 Erection

Long-span structural-plate structures shall be erected in their final position by connecting the plates with bolts at longitudinal and circumferential seams. Drift pins may be used to facilitate matching of holes. All plates shall be placed in the order recommended by the manufacturer with joints staggered so that not more than three plates come together at any one point. All bolts shall be drawn tight, without overstressing, before beginning the backfill.

Steel bolts for structural-plate sections shall be torqued during installation to a minimum of 100 foot-pounds, and a maximum of 300 foot-pounds. The bolts for aluminum structural-plate sections shall be torqued during installation to a minimum of 100 foot-pounds, and a maximum of 200 foot-pounds.

Bolts shall be of sufficient length to completely engage the nut threads.

After steel structures have been erected, all damaged spelter shall be wire brushed and painted as specified in AASHTO M 167.

617A.07
(Reserved)

MEASUREMENT

617A.08
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

The quantity of concrete or reinforcing steel used in thrust beams or additional structural metal or plates used in stiffening ribs or other special structural feature will not be included in the quantities for payment.

Concrete and reinforcing steel for footings, headwalls, and collars or other concrete work will be included under other items as indicated in the SCHEDULE OF ITEMS.

PAYMENT

617A.09
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
617A(01)	Steel Long Span Structures ______ Coated, ______ Span, ______ Rise, ______ Thickness, Shape ______. .	L.F.
617A(02)	Aluminum Long Span Structures ______ Coated, ______ Span, ______ Rise, ______ Thickness, Shape ______. .	L.F.

When materials are furnished by the Forest Service, the note "Government-furnished materials" will be added to the description of the pay item.

Section 619 - Riprap

DESCRIPTION

619.01
Work

This work shall consist of furnishing and placing erosion-resistant and protective materials on the slopes of embankments, dikes, or streambanks, at culvert inlets and outlets, on bottoms and side slopes of channels, at abutment wings, at structure foundations and at other locations SHOWN ON THE DRAWINGS.

MATERIALS

619.02
Hand-Placed,
Machine-Placed,
& Dumped Riprap

Rock used for riprap shall be hard angular rock meeting the following requirements for durability absorption ratio as defined below.

Durability Absorption Ratio	Acceptability
Greater than 23	Passes
10 to 23	Passes only if Durability Index is 52 or greater
Less than 10	Fails

$$\textit{Durability Absorption Ratio} = \frac{\textit{Durability Index (Coarse)}}{\textit{Percent Absorption} + 1}$$

The durability index and percent absorption shall be determined by AASHTO T 210 and AASHTO T 85 respectively. The minimum apparent specific gravity of stone shall be 2.5 as determined by AASHTO T 85.

Neither the breadth nor thickness of any piece of riprap shall be less than one-third its length. Stone shall be free from overburden, spoil, shale, and organic material; shall meet the following gradation requirements for the class specified; and shall be used at the locations SHOWN ON THE DRAWINGS:

Size of Stone	Percent of Total Weight Smaller Than the Given Size
Class I	
25 pounds	100
15 pounds	80
5 pounds	50
1 pound . . . . not to exceed	10
Class II	
50 pounds	100
35 pounds	80
10 pounds	50
2 pounds . . . . not to exceed	10
Class III	
100 pounds	100
60 pounds	80
25 pounds	50
2 pounds . . . . not to exceed	10
Class IV	
150 pounds	100
100 pounds	70
50 pounds	30
10 pounds . . . . not to exceed	10
Class V	
250 pounds	100
150 pounds	70
50 pounds	30
15 pounds . . . . not to exceed	10

Class VI		
400 pounds		100
250 pounds		70
100 pounds		30
20 pounds	not to exceed	10
Class VII		
700 pounds		100
400 pounds		70
200 pounds		30
25 pounds	not to exceed	10
Class VIII		
1,600 pounds		100
800 pounds		70
400 pounds		30
50 pounds	not to exceed	10
Class IX		
2,700 pounds		100
1,600 pounds		70
800 pounds		30
100 pounds	not to exceed	10
Class X		
4,000 pounds		100
2,000 pounds		80
500 pounds		50
70 pounds	not to exceed	10
Class XI		
6,000 pounds		100
3,000 pounds		80
1,000 pounds		50
200 pounds	not to exceed	10

Each load of riprap shall be well graded from the smallest to the maximum size specified.

When allowed in the SPECIAL PROJECT SPECIFICATIONS, stone from the project site may be utilized.

619
.02

Control of gradation will be by visual inspection. When SHOWN ON THE DRAWINGS, the contractor shall provide two samples of the specified class of rock of at least 5 tons each or 10 percent of the total riprap weight, whichever is less. The sample at the construction site may be a part of the finished riprap covering. The other sample shall be provided at the quarry. These samples shall be used as a frequent reference for judging the gradation of the riprap supplied. Any difference of opinion between the Engineer and the contractor shall be resolved by dumping and checking the gradation of two random truck loads of stone. When specified in the SPECIAL PROJECT SPECIFICATIONS, the contractor shall provide mechanical equipment, a sorting site, and labor needed to assist in checking gradation at no additional cost.

619.03 Wire-Enclosed Riprap

Rock used for wire-enclosed riprap shall meet the durability requirements of Subsection 619.02. The rock shall be well graded within the sizes available and 70 percent, by weight, shall exceed in least dimension the wire mesh opening. The maximum size of rock, measured normal to the slope, shall not exceed the mat thickness.

Wire mesh or woven wire, tie wire, and lacing wire shall be galvanized and of the type, quality, and size SHOWN ON THE DRAWINGS. Wire mesh or woven wire shall be furnished in maximum lengths and widths to reduce the number of splices as much as practical. Materials shall meet the requirements of ASTM A 116 "Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way Fencing" Class 1 or better; or FS-QQ-W-461, Finish 5, Class 3 weight of zinc coating.

619.04
Grouted Riprap

Grout for grouted riprap shall consist of one part Portland cement and three parts sand, thoroughly mixed with water to a thick creamy consistency. The minimum amount of water shall be used to prevent excess shrinkage of the grout after placement. The cement and sand shall meet the requirements of Subsection 705.05.

The rocks for grouted riprap shall meet the durability requirements of Subsection 619.02. The size and gradation will be SHOWN ON THE DRAWINGS for each particular project. Rock shall be free of fines that prevent penetration of grout, and care shall be taken when placing the rock to keep earth or sand from filling the spaces between the rocks.

619.05
Sacked Concrete Riprap

(a) Type A sacked concrete riprap shall consist of concrete containing at least three and one-half sacks of cement per cubic yard, aggregate with a maximum size of 2-1/2 inches, and water limited to that necessary to ensure good workability without loss of cement by seepage through the sacks. Reasonably clean and strong aggregate of appropriate size gradation shall be used. Sacks shall be at least 10-ounce burlap or equivalent. Minimum weight of the filled sack shall be 50 pounds. Sacks will be placed while contents are in a moist condition. Premixed concrete, meeting the requirements of this Section, is acceptable.

(b) Type B, (premixed) sacked concrete riprap shall be commercially packaged, dry, combined materials for concrete. The minimum weight for each sack shall be 60 pounds, and each sack shall have an approximate size of 12 by 18 by 6 inches. The strength of each shall be adequate for the mass of concrete it contains. Each sack shall be water permeable. Each sack shall be free of tears and imperfections and the concrete shall not have taken an initial set prior to placing.

619.06
Sacked Soil Cement Riprap

Sacked soil cement riprap may be composed of any combination of gravel, sand, silt, and clay with the following limitations: top soil shall not be used; at least 55 percent of the mixed soil shall pass the No. 4 sieve, with not more than 15 percent passing the No. 200 sieve; and the maximum size gravel shall pass the 1-1/2 inch sieve. Excluding rocks, the soil shall be pulverized so that no lumps exceed 1/2 inch in diameter. The cement, soil, and water shall be thoroughly and uniformly mixed before placing in sacks. Moisture content shall be limited to that necessary for good mixing without seepage. Sacks shall be at least 10-ounce burlap or equivalent. Minimum weight of filled sack shall be 50 pounds. Sacks shall be placed while the contents are in a moist condition.

The cement requirements in percent by volume for each soil group are shown below:

AASHTO Classification (M 145) Soil Group	Percent Cement by Volume
A-1-a	7
A-1-b	9
A-2	10
A-3	12
A-4	12
A-5	13
A-6	14
A-7	15

619.07
Granular Filter Blanket

Filter blanket material shall be in accordance with Subsection 703.01(b).

619.08
Geotextile with Gravel Cushion

Geotextile shall meet the requirements of Section 720 and shall be the function type SHOWN ON THE DRAWINGS. Gravel cushion shall meet the gradation requirements SHOWN ON THE DRAWINGS and the quality requirements of Subsection 703.06.

619.09
Anchor Stakes

Soil-anchor stakes shall be of the type and length SHOWN ON THE DRAWINGS.

CONSTRUCTION

619.10
General

Slopes to be protected by riprap shall be free of brush, trees, stumps, and other objectionable material and shall be dressed to a smooth surface. All soft or spongy material shall be removed to the depth SHOWN ON THE DRAWINGS and replaced with approved material. Backfilled areas shall be compacted as specified in Subsection 203.15, Method 4. A toe trench, if SHOWN ON THE DRAWINGS, shall be dug and maintained until the riprap is placed. The riprap blanket shall be constructed to its full thickness as the placement proceeds up the slope.

All riprap to be located beneath bridge superstructures shall be placed before bridge girders or stringers are installed.

Foundation beds and slopes shall be approved before placing riprap.

When SHOWN ON THE DRAWINGS, a granular filter blanket or geotextile with gravel cushion shall be placed on the prepared slope or area before the stone is placed.

619.11
Hand-Placed Riprap

The rock shall be securely bedded. Spalls and small rocks shall be used to fill voids. Any spaces back of the hand-placed riprap shall be filled with compacted material.

619.12
Machine-Placed Riprap

Riprap stone shall be placed to produce a well-keyed mass of rock with the least practicable amount of void spaces. Rocks shall be placed with their longitudinal axis normal to the embankment face and arranged so each rock above the foundation course has a three-point bearing on the underlying rocks. The foundation course is the course placed on the slope in contact with the ground surface. Bearing shall not be on smaller rocks that may be used for filling voids.

The finished riprap slopes shall present a reasonably uniform and regular surface, free of humps and depressions, and not steeper than SHOWN ON THE DRAWINGS.

619.13
Dumped Riprap (Loose)

Riprap shall be placed to its full course thickness in one operation producing a well-graded uniform mass without displacing the underlying material.

The larger rocks shall be well distributed, and the entire mass of stone shall meet approximately the gradation specified.

The riprap shall be placed in conjunction with the construction of the embankment, with only sufficient lag in placement of the riprap as necessary to allow for proper construction of the protected portion of the embankment and to prevent mixing of embankment and riprap material.

The finished riprap slopes shall present a reasonably uniform and regular surface, free of humps and depressions, and not steeper than SHOWN ON THE DRAWINGS.

619.14
Wire-Enclosed Riprap

Wire enclosure segments shall be placed, anchored, laced, and filled to provide a uniform, dense, protective coat over the area SHOWN ON THE DRAWINGS.

619.15
Grouted Riprap

Rocks shall be thoroughly moistened and any excess of fines shall be sluiced to the underside of the riprap before grouting.

The grout shall be delivered to the place of final deposit by a method that will ensure uniformity and prevent segregation of the grout. The grout shall be spaded or rodded into the interstices to completely fill the voids in the riprap. Pressure grouting shall not unseat the rocks. Penetration of the grout shall be to the depth SHOWN ON THE DRAWINGS. When a rough surface is SHOWN ON THE DRAWINGS, stone shall be brushed until one-quarter to one-half of the depth of surface stone is exposed. For a smooth surface, grout shall fill the interstices to within 1/2 inch of the surface.

Weep holes shall be provided where SHOWN ON THE DRAWINGS.

Where the depth SHOWN ON THE DRAWINGS for grouting is in excess of 12 inches, the riprap shall be placed in lifts of 12 inches or less. Each lift shall be grouted prior to placing the next lift. The succeeding lifts shall be constructed and grouted before the grout in the previous lift has hardened.

Grout shall not be placed in freezing weather or when there is frost on the riprap. Grout shall be protected from freezing and cured in accordance with Section 602.

619.16 Sacked Concrete Riprap

(a) Type A. The sacks, filled with concrete, shall be loosely placed to leave room for folding at the top. The fold shall be just enough to retain the concrete at the time of placing. Immediately after being filled with concrete, the sacks shall be placed and lightly trampled to cause them to conform with the earth face and with adjacent sacks.

All dirt and debris shall be removed from the top of the sacks before the next course is laid thereon. Stretchers shall be placed so the folded ends will not be adjacent. Headers shall be placed with the folds toward the earth face. Not more than four vertical courses of sacks shall be placed in any tier until initial set has taken place in the first course of any such tier.

(b) Type B. Sacks shall be placed and lightly compressed to cause them to conform with the earth surface and with adjacent sacks. Location of placement and special instructions shall be as SHOWN ON THE DRAWINGS. When more than one layer of sacks is required, joints shall be staggered one-half sack width. Not more than four vertical courses (one tier) of sacks shall be placed until initial set has taken place in the first course of any such tier.

After placement, each sack shall be penetrated at least six times from the top through the entire sack thickness, leaving at least a 1/2 to 1 inch diameter void in the concrete mixture. These penetrations shall not damage the sack to the extent that the concrete mixture is spilled or wasted.

When there will not be proper bearing or bond for the concrete because of delays in placing succeeding layers of sacks or because the work is hampered by storms, mud, or other causes, a small trench shall be excavated behind the row of sacks already in place, and the trench shall be filled with fresh concrete before the next layer of sacks is laid.

Sacked concrete riprap shall be kept moist and protected from freezing for a period of 4 days after placement.

619.17 Sacked Soil Cement Riprap

Sack soil cement riprap shall be placed as SHOWN ON THE DRAWINGS.

619.18 Granular Filter Blanket

A filter blanket shall be placed where SHOWN ON THE DRAWINGS to the full specified thickness of each layer in one operation, using methods that will not cause segregation of particle sizes within the layer. The surface of the finished layer shall be reasonably even and free of mounds or windrows. Additional layers of filter material shall be placed in a manner that will not cause mixture of the material in the different layers.

619.19 Geotextile

The geotextile shall be placed as SHOWN ON THE DRAWINGS. The surfaces upon which the geotextile is to be placed shall have a uniform slope, shall be reasonably smooth and free of obstructions, depressions, and debris that could damage the geotextile, and shall be approved prior to placing of geotextile.

The geotextile shall be laid loosely without wrinkles or creases. Adjacent strips shall be sewn or overlapped at joints. Securing pins shall be inserted through both strips of overlapped geotextile at maximum intervals of 3 feet, but not closer than 2 inches to each edge. Displacement of the geotextile shall be prevented.

The installed geotextile shall be approved prior to covering with a gravel cushion or other materials. The gravel cushion shall be carefully placed on the geotextile to the depth SHOWN ON THE DRAWINGS by methods that will not cause damage to the geotextile. Riprap placed on the gravel cushion shall not be dropped a distance greater than 3 feet.

MEASUREMENT

619.20 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Area computations will be based upon surface measurements. Cross sectional measurements of filter blanket material will not exceed the dimensions SHOWN ON THE DRAWINGS.

PAYMENT

619.21 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

619
.18

Pay Item		Pay Unit
619(01)	Hand-Placed Riprap, Class __________	C.Y.
619(02)	Hand-Placed Riprap, Class __________	TON
619(03)	Machine-Placed Riprap Class __________	C.Y.
619(04)	Machine-Placed Riprap Class __________	TON
619(05)	Dumped Riprap, Class _____________	C.Y.
619(06)	Dumped Riprap, Class _____________	TON
619(07)	Dumped Riprap, Class _____________	S.Y.
619(08)	Wire-Enclosed Riprap	C.Y.
619(09)	Wire-Enclosed Riprap	S.Y.
619(10)	Grouted Riprap	C.Y.
619(11)	Grouted Riprap	S.Y.
619(12)	Sacked Concrete Riprap Type __________	C.Y.

619(13)	Sacked Concrete Riprap Type __________	S.Y.
619(14)	Sacked Soil Cement Riprap	C.Y.
619(15)	Sacked Soil Cement Riprap	S.Y.
619(16)	Granular Filter Blanket	C.Y.
619(17)	Geotextile with Gravel Cushion (Function ______, Type _________)	S.Y.
619(18)	Geotextile without Gravel Cushion (Function ______, Type _________)	S.Y.

Section 625 - Seeding & Mulching

DESCRIPTION

625.01 Work

This work shall consist of preparing seedbeds and furnishing and placing required seed, fertilizer, limestone, mulch, and net and blanket material.

MATERIALS

625.02 Requirements

Materials shall meet the requirements of the following Subsections:

Agricultural Limestone	713.02
Fertilizer	713.03
Seed	713.04
Mulch	713.05
Net and Blanket Material	713.07
Water	713.08(a)

Tackifier shall be emulsified asphalt Grade SS-1, SS-1h, CSS-1 or as specified in the SPECIAL PROJECT SPECIFICATIONS.

CONSTRUCTION

625.03 Seeding Seasons

The normal seasonal dates for seeding shall be as specified in the SPECIAL PROJECT SPECIFICATIONS. Seeding materials shall not be applied during windy weather or when the ground is excessively wet or frozen. Work shall be performed during each specified seeding season on all completed and previously untreated sections.

625.04 Soil Preparation

The areas to be seeded shall be finished as required by other applicable Sections to the lines and grades SHOWN ON THE DRAWINGS. Areas that are damaged by erosion or other causes shall be restored. The surface soil shall be in a roughened condition favorable for germination and growth. Limestone, when required, shall be applied uniformly either prior to or after soil preparation at the rate specified in the SPECIAL PROJECT SPECIFICATIONS.

625.05 Application Methods for Seed, Fertilizer, & Limestone

625
.01

Material may be placed by the following methods:

(a) Hydraulic Method. The seed or seed and fertilizer shall be mixed with water in the amounts and mixtures specified in the SPECIAL PROJECT SPECIFICATIONS to produce a slurry and then applied under pressure at the rates specified in the SPECIAL PROJECT SPECIFICATIONS. When wood cellulose or grass straw mulch materials are to be incorporated as an integral part of the slurry mix, they shall be added after all other materials have been thoroughly mixed in the tank.

Legume seed shall be inoculated with approved cultures in accordance with instructions of the manufacturer. The inoculum used for hydraulic seeding shall be four times that recommended for dry seeding.

(b) Dry Method. Mechanical seeders, seed drills, landscape seeders, cultipacker seeders, fertilizer spreaders, or other approved mechanical seeding equipment shall be used to apply the seed or seed and fertilizer in the amounts and mixtures specified in the SPECIAL PROJECT SPECIFICATIONS.

Fertilizer in dry form and ground limestone shall be spread separately at the rates specified in the SPECIAL PROJECT SPECIFICATIONS and incorporated in one operation to the required depth on those areas SHOWN ON THE DRAWINGS.

Hand-operated seeding devices may be used when seed, fertilizer, and ground limestone are applied in dry form.

625.06 Application of Mulch

(a) Hydraulic Method. Wood cellulose or grass straw fiber mulch and fertilizer may be applied in one operation by means of hydraulic equipment that uses water as the carrying agent. A continuous agitator action that keeps the materials in uniform suspension must be maintained throughout the distribution cycle. The discharge line shall provide an even distribution of the solution to the seedbed. Mulching shall not be done in the presence of free surface water. Application to areas SHOWN ON THE DRAWINGS shall start at the top of the slope and work downward. If necessary, the use of extension hoses may be required to reach the extremities of slopes. The rate of application shall be as specified in the SPECIAL PROJECT SPECIFICATIONS.

(b) Dry Method. Mulch shall be applied after seeding and fertilizing are completed, unless otherwise specified in the SPECIAL PROJECT SPECIFICATIONS. The mulch shall be applied uniformly at the rate specified in the SPECIAL PROJECT SPECIFICATIONS.

When a binder is to be used for mulch, the material shall be applied at the rate specified in the SPECIAL PROJECT SPECIFICATIONS. It shall be immediately distributed evenly over the mulch. The contractor shall prevent asphalt adhesive materials from marking or defacing structures, appurtenances, pavements, utilities, or plant growth.

625.07 (Reserved)

625.08 Installation of Netting & Erosion Control Blankets

Nettings and erosion control blankets shall be installed as SHOWN ON THE DRAWINGS and in accordance with the manufacturer's recommendations.

625.09 Care During Construction

The contractor shall be responsible for protecting and caring for seeded areas until final acceptance of the work. The contractor shall repair all damage to seeded areas caused by his construction operations without additional compensation.

MEASUREMENT

625.10 Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Area computations will be upon surface measurements.

PAYMENT

625.11 Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
625(01)	Seeding, Hydraulic Method (without mulch)	ACRE
625(02)	Seeding, Hydraulic Method (without mulch)	M.S.F.
625(03)	Seeding, Hydraulic Method (with mulch)	ACRE
625(04)	Seeding, Hydraulic Method (with mulch)	M.S.F.
625(05)	Seeding, Dry Method (without mulch)	ACRE
625(06)	Seeding, Dry Method (without mulch)	M.S.F.
625(07)	Seeding, Dry Method (with mulch)	ACRE

625(08)	Seeding, Dry Method (with mulch)	M.S.F.
625(09)	Seeding, Hydraulic or Dry Method (with mulch)	ACRE
625(10)	Seeding, Hydraulic or Dry Method (with mulch)	M.S.F.
625(11)	Seeding, Hydraulic or Dry Method (without mulch)	ACRE
625(12)	Seeding, Hydraulic or Dry Method (without mulch)	M.S.F.
625(13)	Seeding and Mulching	ACRE
625(14)	Seeding and Mulching	M.S.F.
625(15)	Mulch (SUPPLEMENTAL APPLICATION)	TON
625(16)	Fertilizer (SUPPLEMENTAL APPLICATION)	TON
625(17)	Seed Mix (SUPPLEMENTAL APPLICATION)	LBS.
625(18)	Netting, Type_____	S.Y.
625(19)	Erosion Control Blanket, Type_____	S.Y.

Section 630 - Gabions

DESCRIPTION

630.01
Work

This work shall consist of furnishing and constructing wire gabion structures.

MATERIALS

630.02
Requirements

Gabions shall be constructed of wire mesh. The wire mesh shall be made of soft tempered galvanized steel wire having a minimum size of 0.120 inch diameter (U.S. Wire Gauge Number 11). The tensile strength of the wire shall be in the range of 60,000 to 85,000 psi. The minimum zinc coating of the wire shall be 0.80 ounces per square foot of uncoated wire surface as determined by tests conducted in accordance with ASTM A 90.

Samples for testing shall include at least one sample of each component of the mesh. Selvedge wire used through all the edges (perimeter wire) shall be not less than nine gauge (U.S.).

Tie wire shall meet the same specifications for wire used in the mesh, except that tie wire for gabion cages shall not be more than two gauges lighter.

630.03
Soil Anchor Stakes

Soil anchor stakes shall be of the type and length SHOWN ON THE DRAWINGS.

630.04
Rock

Rock shall be obtained from sources SHOWN ON THE DRAWINGS. Rocks to be placed in the gabions shall be clean, hard, dense, sound, and of a quality that will resist the action of water or weathering. The smallest dimension of the rocks shall be at least one and one-half times the size of the mesh and up to 12 inches in the greatest dimensions. The rock shall be reasonably well graded between the limiting sizes.

630.05
Geotextile

Geotextile shall meet the requirements of Section 720 and shall be the type SHOWN ON THE DRAWINGS.

630.06
Fabrication

Gabions shall be fabricated so the sides, end, lid and diaphragms can be assembled at the construction site into rectangular baskets of the required sizes. Gabions shall be of single unit construction; the base, ends, and sides shall be woven into a single unit or one edge of these members connected to the base section of the gabion so the strength and flexibility at the point of connection are at least equal to that of the mesh.

Where the length of the gabion exceeds its width, it shall be equally divided into cells by diaphragms of the same mesh and gauge as the body of the gabions. The cell length shall not exceed the width.

All perimeter edges, including diaphragm edges, shall be securely woven or bound so the joints formed by tying shall have approximately the same strength as the body of the mesh.

Gabion lengths shall be integer multiples (2, 3, or 4) of the horizontal width. The heights shall be fractions (1/1, 1/2, or 1/3) of the horizontal width. The horizontal width shall be not less than 36 inches. All gabions shall be of uniform width.

All gabion dimensions are subject to a tolerance limit of plus or minus 3 percent of the manufacturer's stated sizes.

630.07
Mesh Openings

Openings of the mesh shall not exceed 4 inches in the longest dimension.

630.08
Nonraveling Construction

The wire mesh shall be nonraveling. This is defined as the ability to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section of mesh is cut and the section of mesh is then subjected to the load test described in Subsection 630.10.

630.09
Mesh Elasticity

When subjected to the load test described in Subsection 630.10, the wire mesh shall have elasticity sufficient to permit elongation of the mesh equivalent to a minimum of 10 percent of the length of the section of mesh under test without reducing the gauge or tensile strength of individual wire strands to values less than those for similar wire 1 gauge smaller in diameter.

630.10
Load Test

An uncut section of mesh 6 feet in length and not less than 3 feet in width, including all selvedge bindings, shall have the ends securely clamped for 3 feet along the width of the sample. When the width of the section under test exceeds 3 feet, the clamps shall be placed at the center of the width and the excess width will be allowed to fall free on each side of the clamped section. The sample shall then be subjected to tension sufficient to cause 10 percent elongation of the sample section between the clamps. After elongation and while clamped as described above (and otherwise unsupported), the section shall be subjected to a load applied to a one square foot area in the approximate center of the sample section between the clamps and in a direction perpendicular to the direction of the tension force. The sample shall withstand, without rupture of any strand or opening of any mesh fastening, an actual load applied equaling or exceeding 6,000 pounds. The ram head used in the test shall be circular and have its edges beveled or rounded to prevent cutting of the wire strands.

630.11
Certification

Before gabions are installed, the contractor shall furnish a certified report to the Engineer of tests made by an approved testing laboratory showing that materials equal or exceed the above specifications.

This requirement may be waived if the contractor certifies the gabions furnished are of the same specific material and manufacture as previously tested, and for which reports of an approved testing laboratory have already been submitted to the Engineer. Tie and connecting wire shall be supplied in sufficient quantity to securely fasten all edges of the gabion and diaphragms and to provide for four cross-connecting wires in each cell whose height is one-third or one-half the width of the gabion and eight connecting wires in each cell whose height equals the width of the gabion.

630
.08 CONSTRUCTION

630.12
Performance

Excavation and backfill shall be in accordance with Section 206A.

630.13
Gabion Installation

Gabions shall be installed according to the manufacturer's recommendations. The gabions shall be placed on a smooth foundation approved by the Engineer.

Each gabion unit shall be assembled by binding together all vertical edges with wire ties on approximately 6-inch spacing or by a continuous piece of connecting wire stitched around the vertical edges with a coil about every 4 inches. The gabion units shall be set to the lines and grades as SHOWN ON THE DRAWING. Wire ties or connecting wire shall be used to join the units together in the same manner described above for assembling. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure.

Empty gabions shall be stretched to ensure alignment and grade before filling with rock.

The gabions shall be filled with stone carefully placed by hand or machine to ensure alignment and avoid bulges with a minimum of voids. Alternate placing of rock and connection wires shall be performed until the gabion is filled. After a gabion has been filled, the lid shall be bent over until it meets the sides and edges. The lid shall then be secured to the sides, ends, and diaphrams with the wire ties or connecting wire in the manner described above for assembling.

Soil anchor stakes shall be placed as SHOWN ON THE DRAWINGS.

Areas SHOWN ON THE DRAWINGS shall be backfilled with suitable material placed in layers not to exceed 6 inches in thickness and shall be tamped or consolidated to meet the requirements of Section 203.15, Method 4. The gabion structure height may not exceed the backfill by more than 4 feet. All vegetable matter and unstable soil shall be excluded from the backfill. The puddling method of backfilling shall not be used. Existing slopes that might cause a wedge action of the backfill on the gabion wall shall be step cut or benched before backfilling.

630.14
Geotextile
Installation

The geotextile shall be placed as SHOWN ON THE DRAWINGS. The surfaces upon which geotextile is to be placed shall have a uniform slope and shall be reasonably smooth and free of obstructions, depressions, and debris that could damage the geotextile. The surface shall be approved by the Engineer prior to placing of geotextile.

The geotextile shall be laid loosely without wrinkles or creases. Adjacent strips shall be sewn or overlapped a minimum of 12 inches at joints. Securing pins shall be inserted through both strips of overlapped geotextile at maximum intervals of 3 feet, but no closer than 2 inches to each edge, to prevent displacement of the geotextile.

The installed geotextile shall be approved by the Engineer prior to covering.

MEASUREMENT

630.15
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS. Area computations will be based upon surface measurements. Overlap quantities will not be included.

PAYMENT

630.16
Basis

The accepted quantities will be paid at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
630(01)	Gabions	C.Y.
630(02)	Geotextile (Function ______, Type _______). . . .	S.Y.

Section 633 - Signs

DESCRIPTION

633.01
Work

This work shall consist of installing only or furnishing and installing delineators, signs, sign supports, panels, and posts or removing and disposing of existing signs, posts and hardware.

633.02
Traffic Control Sign Details

Traffic control sign details not SHOWN ON THE DRAWINGS shall meet the requirements of the MUTCD.

MATERIALS

633.03
Requirements

Materials shall meet the requirements of the following subsections:

Sign Panels	718.01
Posts	718.02
Fittings	718.03
Reflective Materials	718.04
Letters, Numerals, Arrows, Symbols, Borders	718.05
Delineators	718.06

All concrete shall meet the requirements of Section 602, Method B or C as SHOWN ON THE DRAWINGS.

Reinforcing steel as SHOWN ON THE DRAWINGS shall meet the requirements of Subsection 709.01.

CONSTRUCTION

633.04
Fabrication of Sign Panels

Fabrication of all parts shall be accomplished in a uniform manner. All panel fabrication, including cutting, punching, and drilling of holes, shall be completed prior to final surface preparation and application of reflective sheeting, except where required for the fabrication of diecut or sawed letters on processed and mounted signs. Metal panels shall be cut to size and shape and shall be free of buckles, warp, dents, cockles, burrs, and defects resulting from fabrication. The surface of all sign panels shall be flat.

Field drilling of holes in any part of the structural assembly will not be permitted without the approval of the Engineer.

(a) Aluminum Panels. Aluminum sign panels shall be fabricated from standard widths of aluminum sheet. The thickness shall be in accordance with Subsection 718.01(b) unless otherwise SHOWN ON THE DRAWINGS.

The blanks shall be cleaned, degreased, and chromated or otherwise properly prepared in accordance with approved methods recommended by the sheeting manufacturer.

(b) Steel Panels. The finished plate for steel panels shall be free of twist or buckle, and the background shall be substantially a plane surface. The finished sign panel shall be of continuous coat mill-galvanized phosphate-coated steel that meets the requirements of Subsection 718.01(c). The panels shall be cleaned, degreased, or otherwise prepared in accordance with approved methods recommended by the sheeting manufacturer.

(c) Plywood Panels. The face of the plywood panel shall be abraded, cleaned, and degreased in accordance with approved methods recommended by the manufacturer of the reflective sheeting. The edges of the plywood panel shall be sealed with 2 mil dry film thickness, (in 2 coats); one coat shall be applied before application of reflective sheeting, the other, after.

Paint used shall be ready-mixed, exterior type, polysilicone alkyd resin base enamel, Benjamin Moore No. 120-60 (Federal color chip no. 20059).

(d) Durability Treatment. After all reflective sheeting legend has been applied, sign panels with Type II sheeting shall be recycled in the heat and vacuum applicator for 2 minutes at a temperature of approximately 190 °F under 21 inches of vacuum. When the sign panel has cooled, the top edge of each sign shall be covered with a clear 3-inch wide polyester film with a sun-resistant, pressure-sensitive adhesive that does not turn yellow under exposure to ultraviolet radiation. Scotchcal Brand Film #639 or Engineer approved equal shall be used. Film shall be applied in lengths of 24 inches. Where more than one piece is required, film shall be applied from each corner of the top edge toward the center of the top edge. End overlap of 2 inches or more shall be required where one film piece joins another piece.

633.05
Delineator Posts & Housing

Delineator posts shall be driven at locations and to the depth SHOWN ON THE DRAWINGS. The delineator housing shall be attached to the post in accordance with the manufacturer's direction.

633.06
Sign Erection

Sign supports shall be erected plumb and in accordance with the details SHOWN ON THE DRAWINGS.

The sign panels shall be securely fastened to the posts as SHOWN ON THE DRAWINGS.

To reduce specular glare, sign panel face shall be erected in accordance with MUTCD.

633.07
Sign Removal

Sign assemblies to be removed shall be SHOWN ON THE DRAWINGS. Where signs are to be replaced, signs shall be removed just before the installation of replacement signs. All sign material removed shall become the property of the contractor. Posts shall be removed to a minimum of 3 inches below natural ground line. Post holes remaining shall be backfilled with suitable material and compacted.

MEASUREMENT

633.08
Method

The method of measurement, as described in Section 106, will be DESIGNATED in the SCHEDULE OF ITEMS.

Quantities of sign face area will be computed using the dimensions SHOWN ON THE DRAWINGS.

No deduction will be made for rounded corners.

The area for irregularly shaped signs, such as "Stop" signs, will be computed by multiplying the extreme width by the extreme height of the sign face.

For sign removal, an assembly of posts and signs shall be considered as only one sign when these materials are integrally connected and standing at one location.

PAYMENT

633.09
Basis

The accepted quantities will be paid for at the contract unit price for each pay item shown in the SCHEDULE OF ITEMS.

Payment will be made under:

Pay Item		Pay Unit
633(01)	Wood Posts	L.F.
633(02)	Steel Posts	L.F.

633(03)	Aluminum Posts	L.F.
633(04)	Aluminum Sign Panels	S.F.
633(05)	Plywood Sign Panels	S.F.
633(06)	Steel Sign Panels	S.F.
633(07)	Delineators	EA.
633(08)	Sign	EA.
633(09)	Sign Removal	EA.
633(10)	Sign and Post(s), Installation Only	EA.
633(11)	Regulatory Signs	EA.
633(12)	Warning Signs & Markers	EA.

SECTION 700 MATERIALS DETAILS

700

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Section 701 - Cement, Grout, & Mortar

701.01 Cement

Cement shall meet the requirements of the following specifications:

(a)	Portland cement	AASHTO M 85
(b)	Blended hydraulic cements excluding Types S and SA	AASHTO M 240
(c)	Masonry cement	AASHTO M 150

Fly ash or pozzolan may be substituted for Portland cement providing that the proportions of cement and fly ash or pozzolan conform to the requirements of Sections 552 or 602.

When blended cement (AASHTO M 240) is proposed for use, all requirements for fly ash modified concrete in the applicable sections shall apply.

Fly ash or pozzolan materials shall conform to the requirements of Subsection 712.04.

The product of only one manufacturing plant and only one brand of any one type of Portland cement shall be used on the project.

The cement shall be stored and protected against dampness. Cement that for any reason has become partially set or that contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

701.02 Grout

Grout shall be packaged and ready for use with the addition of water at the construction site. Each bag shall be stamped to show the latest date at which it may be used. The product shall consist of a hydraulic cementitious system, graded and processed natural fine aggregate and additional technical components meeting the following:

(a) Free of inorganic accelerators, including chlorides.

(b) Free of oxydizing catalysts.

(c) Free of gas-producing agents.

(d) The grout, when mixed to 130 percent flow on flow table (ASTM C 230 at 10 drops), shall not reduce in linear dimension when tested in accordance with ASTM C 157. Measurements shall be taken at 72 hours and 7 days.

(e) No bleeding shall be present for the first 2 hours after mixing when mixed to 130 percent flow on flow table (ASTM C 230 at 10 drops), as tested in accordance with ASTM C 232.

(f) Provide performance characteristics at 115 to 120 percent flow on flow table (ASTM C 230 at 10 drops), and minimum strength of grout shall be as follows when tested in accordance with ASTM C 109:

72 hours - 3,500 psi
7 days - 5,500 psi
28 days - 7,000 psi

(g) Manufacturer must state that the product is designed to be mixed, placed, and cured at atmospheric temperatures of 40 °F to 90 °F. Products proposed by the contractor for use shall be submitted for Engineer's approval and shall be accompanied by manufacturer's submittals substantiating all requirements of this section, including (1) graphs or charts showing the time, temperature, and humidity curing requirements to achieve the specified grout strengths; and (2) recommendations for storage, mixing, application, and curing procedures.

701.03
Mortar

Mortar shall be packaged and ready for use with the addition of water at the construction site. Each bag shall be stamped to show the latest date at which it may be used. The product shall consist of a cementitious system made up of:

(a) Natural 3/8-inch maximum size aggregate, meeting ASTM C 33 except for grading, which shall be accomplished by blending of sieve sizes to get the optimum density.

(b) Metallic aggregate free from nonferrous material, soluble alkaline compounds, and visible rust.

(c) Water reducers, workability agents, air-entraining agents and catalysts.

The materials shall be blended to minimize bleeding, increase workability, resist exposure to freeze-thaw cycles and deicing salts, and shall prevent shrinkage within and at the perimeter of the patch, keyway, or other area to be filled.

The minimum compressive strength of the mortar, as tested by ASTM C 109 for a 3-inch slump, shall be:

24 hours	5,000 psi
7 day	9,000 psi
28 days	10,000 psi

The durability of the products when tested at 300 cycles, ASTM C 666 procedure A, shall be:

Submerged in:	DF (%)
Water	98
5% $CaCl_2$	95
5% NaCl	85

The scaling resistance shall have a rating of 3-Moderate Scaling after 50 cycles when tested according to ASTM C 672.

The manufacturer must certify that the product is compatible for work that is 1 inch or more in depth and over 1 inch in width; and where the mixing, placing, and curing temperatures may range from 40 °F to 90 °F.

Products proposed by the contractor for use shall be submitted for Engineer's approval and shall be accompanied by manufacturer's submittals substantiating all requirements of this Section, including (1) graphs or charts showing the time, temperature, humidity, and curing requirements to achieve mortar strengths equal to the adjacent concrete; and (2) complete recommendations for storage, mixing, application, and curing procedures.

Section 703 - Aggregates

703.01 Fine Aggregate

(a) Structural Concrete. Fine aggregate shall meet the requirements of AASHTO M 6, except that:

(1) The soundness test is not required.

(2) There shall be no deleterious substances in excess of the following percentages:

Clay lumps and friable particles	3.0
Coal and lignite, as defined in 7.1.6 of AASHTO M 80 . .	1.0
Material passing the Number 200 sieve	7.0

(3) Fine aggregate shall not contain any materials that are deleteriously reactive with the alkalies in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the fine aggregate may be used with a cement containing less than 0.6 percent alkalies calculated as sodium oxide or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction (see AASHTO M 80).

(4) The Minimum Sand Equivalent determined by AASHTO T 176 (Alternative method Number 2) shall be 75.

Lightweight aggregate, if required or permitted by the SPECIAL PROJECT SPECIFICATIONS, shall meet the requirements of AASHTO M 195.

(b) Granular Backfill Filter Material. Granular backfill filter material for underdrains and drainage blankets shall be permeable, shall meet the gradation SHOWN ON THE DRAWINGS, and shall meet the quality requirements for crushed aggregate base shown in table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(c) Aggregate for minor concrete structures shall meet the requirements of AASHTO M 80 and M 6. Coarse aggregate size shall be as SHOWN ON THE DRAWINGS.

703.02 Coarse Aggregate

Coarse aggregate for concrete shall meet the requirements of AASHTO M 80, aggregate Class A, with the following modifications and additions unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(a) Gradation shall meet the requirements of table 703-1 for the specified classes of concrete.

(b) Subsection 6.3 of AASHTO M 80 is deleted.

(c) The following words are deleted from the first sentence of 6.2 of AASHTO M 80: ". . . that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground. . . ."

Lightweight aggregate, if required or permitted by the SPECIAL PROJECT SPECIFICATIONS, shall meet the requirements of AASHTO M 195.

703.03 (Reserved)

703.04 Aggregate for Road Mix Bituminous Base

Aggregates for road mix bituminous base construction shall be crushed stone, crushed slag, or crushed or natural gravel meeting the quality requirements of table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

The gradation shall be as described in the SPECIAL PROJECT SPECIFICATIONS. When crushed gravel is used, not less than 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face.

Table 703-1.--Coarse aggregate requirements for structural concrete.

AASHTO M 43 Size Number	Nominal Size Range	Percentage by Weight Passing Square Mesh Sieve Size (AASHTO T 27)									
		3 in	2-1/2 in	2 in	1-1/2 in	1 in	3/4 in	1/2 in	3/8 in	No. 4	No. 8
7	1/2 in --No. 4	--	--	--	--	--	100	90--100	40--70	0--15	0--5
67	3/4 in --No. 4	--	--	--	--	100	90--100	--	20--55	0--10	0--5
57	1 in --No. 4	--	--	--	100	95--100	--	25--60	--	0--10	0--5
467	1-1/2 in --No. 4	--	--	100	95--100	--	35--70	--	10--30	0--5	--
357	2 in --No. 4	--	100	95--100	--	35--70	--	10--30	--	0--5	--
	2-1/2 in --No. 4	--	95-100	--	35--70	--	10--30	--	--	0--5	--
4	1-1/2 in --3/4 in	--	--	100	90--100	20--55	0--15	--	0--5	--	--
3	2 in --1 in.	--	100	95--100	35--70	0--15	--	0--5	--	--	--
2	2-1/2 in --1-1/2 in	100	90--100	35-- 70	0--15	--	0--5	--	--	--	--

703.05
(Reserved)

703.06
Aggregate for Base or Surface Courses

Aggregate materials shall conform to the requirements shown below unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(a) Pit-Run Aggregate. Pit-run aggregates shall consist of native materials of a size and grading that can be taken directly from the source and placed on the road without crushing or screening. No gradation, other than a maximum size, will be required. The maximum size shall be as shown in the SCHEDULE OF ITEMS.

(b) Grid-Rolled Aggregate. Grid-rolled aggregate shall consist of native materials of a quality that can be taken directly from the source, without crushing or screening, and broken down on the road by grid-rolling. No gradation other than a maximum size will be required. The maximum size shall be as shown in the SCHEDULE OF ITEMS.

(c) Screened Aggregate. Material shall consist of gravel, talus, rock, sand, shale, or other suitable material, and be reasonably hard and durable and reasonably free of organic material, mica, clay lumps, or other deleterious materials. The gradation requirements shall be as shown in the SCHEDULE OF ITEMS.

(d) Crushed Aggregate. Aggregate for crushed base or surface courses shall be crushed stone, slag, or gravel meeting the requirements shown in table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS, the crushed aggregate gradation shall meet the requirements of table 703-4 for the grading shown in the SCHEDULE OF ITEMS. Aggregate shall be well graded from coarse to fine within the gradation band.

Table 703-3.--Crushed aggregate quality requirements for base or surface courses.

Description	AASHTO Test Method	Requirement	
		Base	Surfacing
Percent Wear	T 96	40 max.	40 max.
Durability Index, Coarse and Fine	T 210	35 min.	35 min.
Liquid Limit	T 89	25 max.	35 max.
Plasticity Index	T 90	6 max.	2--9 max.
Dust Ratio: $\frac{\text{\% Passing No. 200}}{\text{\% Passing No. 30}}$	T 11 T 27	2/3 max.	2/3 max.
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.	--

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. Naturally fractured faces may be included in the 50 percent requirement, provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Table 703-4.--Crushed aggregate grading requirements for base or surface courses.

Sieve	Percent Passing (AASHTO T 11 and T 27)				
	Grading A	Grading B	Grading C	Grading D	Grading E
3-Inch	100				
2-Inch	65-95	100			
1-1/2-Inch			100		
1-Inch		60-90		100	
3/4-Inch	40-75		60-90	70-98	100
1/2-Inch		44-70			70-98
No. 4	22-45	28-50	30-55	36-60	44-70
No. 8	16-34	20-41	22-43	25-47	30-54
No. 30	8-22	9-26	11-27	12-31	15-34
No. 200	2-10[a]	3-12[a]	3-15[a]	3-15[a]	3-15[a]
Sieve	Grading F	Grading G	Grading H	Grading J	Grading K
3-Inch	100				
2-Inch	65-95	100			
1-1/2-Inch			100		
1-Inch		50-85		100	
3/4-Inch	28-70		55-90	70-98	100
1/2-Inch		27-60			65-95
No. 4	10-35	15-40	20-48	25-55	33-60
No. 8				16-40	21-42
No. 30			5-20	6-22	8-24
No. 200	0-10[a]	0-12[a]	0-15[a]	0-15[a]	0-15[a]
Sieve	Grading L	Grading M	Grading N	Grading O	
6-Inch	100				
4-Inch		100			
3-Inch			100		
2-Inch				100	
1-1/2-Inch					
1-Inch					
3/4-Inch					
1/2-Inch					
No. 4		15-45	15-45		
No. 8					
No. 30					
No. 200					

[a] For untreated base used under bituminous materials, Sections 403, 404, 405, 406, and 410, the maximum percent passing the Number 200 sieve shall be eight. For surfacing, the minimum percent passing the Number 200 sieve shall be six.

703
.06

703.07
Aggregate for Hot Bituminous Pavement

Aggregates for hot bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-5, unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one mechanically fractured face.

The pavement aggregate gradation shall meet the requirements of table 703-6 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-5.--Crushed aggregate quality requirements for hot bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Sand Equivalent (Alternative Method Number 2)	T 176	45 min.
Stripping Test	T 182	Min. 95% coated[a]

[a] An approved chemical additive may be used to meet this requirement.

Table 703-6.--Crushed aggregate grading requirements for hot bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)			
	Grading A	Grading B	Grading C	Grading D
1-1/2-Inch	100			
1-Inch	95-100	100		
3/4-Inch	78-95	95-100	100	
1/2-Inch		68-86	95-100	100
3/8-Inch	54-75	56-78	74-92	95-100
No. 4	36-58	38-60	48-70	75-90
No. 8	25-45	27-47	33-53	62-82
No. 16		18-37	22-40	38-58
No. 30	11-28	13-28	15-30	22-42
No. 50		9-20	10-20	11-28
No. 200	0-8	4-8	4-9	2-10

703.08
(Reserved)

703.09
(Reserved)

703.10
Aggregate for Cold Bituminous Pavement

Aggregates for cold bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-7 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

When crushed gravel is used for dense- or intermediate-graded cold bituminous pavement, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. At least 70 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face for open-graded cold bituminous pavement. Naturally fractured faces may be included in the percentage requirement provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Aggregate gradation shall meet the requirements of Table 703-8 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-7.--Crushed aggregate quality requirements for cold bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.
Stripping Test	T 182	min. 95% coated

Table 703-8.--Crushed aggregate grading requirements for cold bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)			
	Dense-Graded	Intermediate-Graded	Open-Graded	Top Dressing
1-Inch	100	100	100	
3/4-Inch	80-100	70-100	70-90	
1/2-Inch	60-85	50-70	40-70	
3/8-Inch				100
No. 4	35-60	15-35	0-10	
No. 8	23-44	11-23	0-7	
No. 16				30-60
No. 30	9-25	3-12	0-5	
No. 200	2-8	0-3	0-2	0-4

703.11 Aggregate for Road Mix Bituminous Pavement

Aggregates for road mix bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-9 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-9.--Crushed aggregate quality requirements for road mix bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Stripping Test	T 182	min. 95% coated[a]
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.

[a] An approved chemical additive may be used to meet this requirement.

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. Naturally fractured faces may be included in the 50 percent requirement provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Aggregate gradation shall meet the requirement of table 703-10 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-10.--Crushed aggregate grading requirements for road mix bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)
1-Inch	100
3/4-Inch	80-100
1/2-Inch	60-85
No. 4	35-60
No. 8	23-44
No. 30	9-25
No. 200	2-8

703.12
(Reserved)

703.13
Aggregate for Surface Treatments

Crushed stone shall consist of clean, tough, durable fragments, free from an excess of flat, elongated, soft, or disintegrated pieces and free from stone coated with dirt or other objectionable matter. Aggregate shall meet the quality requirements shown in table 703-11 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Aggregate for bituminous surface treatments shall meet the requirements of table 703-12 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

703.14
Blotter

Unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS, aggregate for blotter material shall meet the gradation requirements shown in table 703-13 and shall be granular material free from organic matter and other deleterious materials with a minimum sand equivalent value of 45 measured by AASHTO T 176, Alternate Method Number 2.

Table 703-11.--Crushed aggregate quality requirements for surface treatments.

AASHTO Description	Test Method	Bituminous Surface Treatment Section 410
Percent wear	T 96	40 max.
Stripping Test[a]	T 182	min. 95% coated[a]
Durability Index	T 210	35 min.
One Mechanically Fractured Face, by Weight of Plus No. 8		50% min.

[a] An approved chemical additive may be used to meet this requirement.

703.15
Bed Course Material & Mineral Filler

(a) Bed course material for sidewalks, paved waterways and curbing shall consist of cinders, sand, slag, gravel, crushed stone, or other material specified in the SPECIAL PROJECT SPECIFICATIONS.

(b) Bed course material for slope protection shall be a free draining material consisting of sand, gravel, cinders, slag, crushed stone, or other material specified in the SPECIAL PROJECT SPECIFICATIONS.

(c) Mineral filler shall meet the requirements of AASHTO M 17.

Table 703-12.--Crushed aggregate grading requirements for surface treatments.

Sieve	Percent Passing (AASHTO T 11 and T 27)				
	Grading 6	Grading 6A	Grading 7	Grading 7A	Grading 7B
1-Inch	100	100			
3/4-Inch	90-100	95-100	100	100	100
1/2-Inch	20-55	0-20	90-100	95-100	70-98
3/8-Inch	0-15	0-5	40-70	0-30	
1/4-Inch				0-5	
No. 4	0-5		0-15		44-70
No. 8			0-5		30-54
No. 16		0-0.5		0-0.5	
No. 30					15-34
No. 200	0-2		0-2		0-2
Sieve	**Grading 8**	**Grading 8A**	**Grading 9**	**Grading 9A**	
1-Inch					
3/4-Inch					
1/2-Inch	100	100			
3/8-Inch	85-100	95-100	100		
1/4-Inch		0-40		100	
No. 4	10-30	0-5	85-100	95-100	
No. 8	0-10		10-40	0-40	
No. 16	0-5	0-0.5	0-10	0-0.5	
No. 30			0-5		
No. 200	0-2		0-2		

Table 703.13--Requirements for grading blotter material.

Sieve	Percent Passing (AASHTO T 11 and T 27)	
	Grading A	Grading B
3/8	100	100
No. 4	85-100	
No. 16	30-80	
No. 200	0-4	

703
.15

Section 705 - Joint Materials

705.01
Joint Fillers

Poured filler for joints shall meet the requirements of AASHTO M 173 or as SHOWN ON THE DRAWINGS.

Preformed filler for joints shall meet the requirements of AASHTO M 33, AASHTO M 153, or AASHTO M 213 and shall be punched as SHOWN ON THE DRAWINGS to admit the dowels. The filler for each joint shall be furnished in a single piece according to the depth and width required for the joint. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held in position by stapling or other positive fastening approved by the Engineer.

705.02
Joint Mortar

Pipe joint mortar shall consist of one part Portland cement and two parts sand, with water added as necessary to obtain the required consistency. Portland cement and sand shall meet the requirements of Subsections 701.01 and 703.01(a), respectively. Mortar shall be used within 30 minutes after its preparation.

705.03
Rubber Gaskets

Ring gaskets for rigid pipe shall meet the requirements of AASHTO M 198. Continuous flat gaskets for flexible metal pipe shall meet the requirements of ASTM D 1056, with grade RE 41 used for bands with projections or flat bands and grade RE 43 used for corrugated bands. When used with metal pipe with annular reformed ends, the ring gasket shall be one-fourth greater in diameter than the depth of the corrugation. Gasket thickness for bands with projections or flat bands shall be 1/2 inch greater than the nominal depth of the corrugation and shall be 3/8 inch for corrugated bands. For pipe with flanged ends, a butyl rubber strip gasket shall be placed inside the channel band.

705.04
Oakum

Oakum, for joints in bell and spigot pipe, shall be made from either hemp (Cannabis sativa) line, Benares Sunn fiber, or from a combination of these fibers. The oakum shall be thoroughly corded and finished and free from lumps, dirt, and extraneous matter.

705.05
Mortar for Masonry Beds & Joints

(a) Composition. Masonry mortar shall be composed of one part Portland cement or air-entraining Portland cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to 10 percent of the cement by weight. Instead of air-entraining cement, Portland cement may be used with an air-entraining admixture in accordance with Section 602.

For masonry walls not exceeding 6 feet in height, a mortar composed of one part masonry cement and two parts fine aggregate by volume may be substituted for the above mixture of Portland cement, lime, and fine aggregate.

(b) Materials. Type I or Type IA air-entraining Portland cement, meeting the requirements of AASHTO M 85, may be used, except when the contract contains an item for concrete under Section 602, the contractor may use the same type as is used for that work.

Masonry cement shall meet the requirements of AASHTO M 150.

Fine aggregate shall meet the requirements of AASHTO M 45.

Hydrated lime shall meet the requirements for residue, popping and pitting, and water retention shown for Type N in ASTM C 207.

Water shall meet the requirements of Subsection 712.01.

Air-entraining agents shall meet the requirements of Subsection 711.02.

705.06
(Reserved)

705.07 Rubber Waterstops

Rubber waterstops may be molded or extruded and shall have a uniform cross section, free from porosity or other defects, conforming to the nominal dimensions SHOWN ON THE DRAWINGS. An equivalent standard shape may be furnished, if approved by the Engineer.

The waterstop may be compounded from natural rubber, synthetic rubber, or a blend of the two, together with other compatible materials which will produce a finished waterstop meeting the requirements tabulated in table 705-1. No reclaimed material shall be used. The contractor shall furnish a certificate from the manufacturer to show the general composition of the material and values for the designated properties in table 705-1. The contractor shall also furnish samples, in lengths adequate for making designated tests, as ordered by the Engineer.

Table 705-1.--Required properties and test methods, finished rubber waterstop.

Property	Federal Test Method Standard No. 601	Requirement
Hardness (by Shore Durometer)	3021	60 to 70
Compression Set	3311	30% max.
Tensile Strength	4111	2,500 psi min.
Elongation at Breaking	4121	450% min.
Tensile Stress at 300% Elongation	4131	900 psi min.
Tensile Strength After Aging	7111	80% original min.

705.08 Plastic Waterstops

Plastic waterstops shall be fabricated with a uniform cross section, free from porosity or other defects, to the nominal dimensions SHOWN ON THE DRAWINGS. An equivalent standard shape may be furnished, if approved by the Engineer.

The material from which the waterstop is fabricated shall be homogeneous elastomeric, plastic compound of basic polyvinylchloride and other material that, after fabrication, will meeet the requirements of table 705-2. No reclaimed material shall be used. The contractor shall furnish a certificate from the manufacturer showing values for the designated properties in table 705-2. The contractor shall furnish samples, in lengths adequate for making designated tests, as requested by the Engineer.

705.09 Flexible Plastic Gaskets

Flexible plastic gaskets shall conform to AASHTO M 198, Type B, shall be produced from blends of refined hydrocarbon resins and plasticizing components reinforced with inert mineral filler, and shall contain no solvents. The gasket joint sealer shall be supplied in extruded rope form of suitable cross section and size as to fill the joint space when the pipes are joined.

705.10 Bituminous Mastic

Bituminous mastic joint sealing material shall be a smooth, uniform mixture of bituminous cement, solvent, and mineral filler. The mineral filler shall consist essentially of short fiber asbestos. The mixture shall be readily applicable by means of a trowel or calking gun without pulling or drawing, and shall not sag or flow when applied to metal, concrete, or vitrified clay surfaces.

The compound shall be capable of withstanding freezing and shall not exhibit any tendency to separate or otherwise deteriorate while in storage.

Table 705-2.--Required properties and test methods, finished plastic waterstop.

Property	Federal Test Method Standard No. 406	ASTM Equivalent	Requirement
Tensile Strength	1011	D 638	Minimum 1,400 psi
Elongation at Breaking	1011	D 638	Minimum 250 percent
Hardness (Shore Durometer)	1082	D 1706	60 to 75
Specific Gravity	5011		Maximum ±0.02 from manufacturer's value
Resistance to Alkali (7 days using 10 percent NaOH)	7011	D 543	Maximum weight change: -0.10 percent to +0.25 percent Maximum hardness change ±5 (Shore); maximum tensile strength decrease: 15 percent
Water Absorption (48 hours)	7031	D 570	Maximum 0.5 percent
Cold Bending	(a)	(a)	No cracking
Volatile Loss	6081	D 1203	Not more than manufacturer's value

(a) = The cold bend test will be made by subjecting a 1-inch by 6-inch by 1/8-inch strip of plastic waterstop to a temperature of -20 °F for 2 hours. The strip will immediately thereafter be bent 180 degrees around a rod of 1/4-inch diameter by applying sufficient force to hold the sample in intimate contact with the rod. The sample will then be examined for evidence of cracking. At least three individual samples from each lot will be tested and the result reported.

When applied to a tinned panel or glass plate, in a layer 1/16 to 1/8-inch thick, and cured at room temperature for 24 hours, the compound shall set to a tough, plastic coating and shall not shrink, crack, or loosen from the surface.

In addition, the material shall comply with the requirements of the following table:

	Min.	Max.
Grease Cone Penetration (ASTM D 217 Unworked, 150 gm., 25 °C., 5 sec.) 0.10 mm...	175	250
Weight per gal, lbs................	9.75	---
Non-Volatile (10 gm, 105 °C - 110 °C., 24 hrs), pct.....	75	---
Ash (by ignition), pct.............	25	45

705.11 Preformed Plastic Sealing Compound

Preformed plastic sealing compounds for concrete pipe joints shall meet the requirements of AASHTO M 198.

Section 707 - Metal Pipe

707.01
Corrugated Steel Pipe & Pipe Arches

(a) Riveted Pipe and Pipe Arches. These pipes shall meet the requirements of AASHTO M 36.

(b) Welded Pipe and Pipe Arches. Corrugated metal pipe and pipe arches fabricated by resistance spot welding shall meet the applicable requirements of AASHTO M 36.

(c) Helical Pipe. Helically corrugated pipe with continuous lock or welded seams shall meet the applicable requirements of AASHTO M 36.

(d) Coupling Bands. Coupling bands shall meet the requirements of AASHTO M 36.

(e) Special Sections. Special sections such as elbows, tees, wyes, etc., shall be the same thickness as the conduit to which they are joined and meet the applicable requirements of AASHTO M 36.

(f) Flared End Sections. Flared end sections for inlet and outlet ends of pipe and pipe arch culverts shall meet the applicable requirements of AASHTO M 36. End sections shall be fabricated in accordance with the details and dimensions SHOWN ON THE DRAWINGS, except minor variations may be accepted to permit the use of the manufacturer's standard methods of fabrication.

707.02
Bituminous-Coated Corrugated Steel Pipe & Pipe Arches

These conduits and their coupling bands shall meet the requirements of AASHTO M 190. The coating shall be Type A, B, C, or D as shown in the SCHEDULE OF ITEMS. Coupling bands shall be fully coated with bituminous material. Pipe shall be made from material conforming to AASHTO M 218 zinc coated, AASHTO M 274 aluminum coated, or AASHTO M 289 aluminum-zinc coated.

Special sections, such as elbows and prefabricated flared end sections, shall meet the applicable requirements of AASHTO M 190. Coating and invert paving shall be of the type specified. Flared end sections shall meet the requirements of AASHTO M 243 or M 190 for the coating specified. The Engineer may waive the imperviousness test for coated pipe if no separation of coating from metal is observed.

When asbestos-bonded bituminous coating is specified, the above requirements shall apply; in addition, the special process of embedding asbestos fiber in the molten metallic bonding medium shall be used to bond the bituminous coating. Asbestos-bonded corrugated metal pipe shall be fabricated in accordance with AASHTO M 36 using asbestos-bonded sheets of base metal specified therein. Both sides of the metal sheets shall be coated with a layer of asbestos fibers pressed into the molten zinc bonding medium. Immediately after the metallic bond has solidified, the asbestos fibers shall be thoroughly impregnated with a bituminous saturant. The finished sheets shall be uniformly coated and free from blisters. After fabrication, the culvert sections shall be treated as specified for Type A, B, or C in accordance with AASHTO M 190. Coupling bands shall meet the requirements of AASHTO M 36.

707.03
Polymeric-Precoated Steel Pipe, Pipe Arches, & Underdrains

(a) Pipe shall meet the requirements of AASHTO M 245.

(b) Coupling bands shall meet the requirements of AASHTO M 245 and M 246. Coating shall be Type A or B as shown in the SCHEDULE OF ITEMS.

(c) Special sections such as elbows, tees, wyes, etc., shall be the same thickness as the conduit to which they are joined.

(d) Flared end sections for attachment to the inlet and outlet ends of pipe and pipe arch culverts shall meet the applicable requirements of AASHTO M 243 and M 246. End sections shall be fabricated in accordance with the details and dimensions SHOWN ON THE DRAWINGS, except that minor variations may be accepted to permit the use of the manufacturer's standard methods of fabrication.

707.04
Corrugated Steel Pipe for Underdrains, Plain Galvanized or Precoated

Plain galvanized pipe shall meet the requirements of AASHTO M 36. Precoated underdrains shall meet the requirements of AASHTO M 245.

707.05
Bituminous-Coated Steel Pipe for Underdrains

Pipe shall meet the requirements of AASHTO M 36 and shall be coated with bituminous material to meet the requirements of AASHTO 190, Type A coating, except that minimum coating thickness shall be 0.03 inch. Coupling bands shall be fully coated. The specified minimum diameter of perforations shall apply after coating. The Engineer may waive the imperviousness test if no separation of coating from metal is observed.

707.06
Corrugated Aluminum Alloy Culvert Pipe & Pipe Arches

Pipe shall meet the requirements of AASHTO M 196.

707.07
Corrugated Aluminum Alloy Pipe for Underdrains

Pipe shall meet the requirements of AASHTO M 196.

707.08
Bituminous-Coated Corrugated Aluminum Alloy Culvert Pipe & Pipe Arches

Pipe shall meet the requirements of AASHTO M 196 and shall be coated with bituminous material meeting the requirements of AASHTO M 190.

707.09
Bituminous-Coated Corrugated Aluminum Alloy Pipe Underdrains

Pipe shall meet the requirements of AASHTO M 196 and shall be coated with bituminous material meeting the requirements of AASHTO M 190.

707.10
Structural Steel Plate for Pipe, Pipe Arches, & Arches

The plates and bolts and nuts for connecting plates shall meet the requirements of AASHTO M 167.

707.11
Full Bituminous-Coated Structural-Plate Pipe, Pipe Arches, & Arches

Plates shall meet the requirements of AASHTO M 167 and shall be coated with bituminous material meeting the requirements of AASHTO M 243.

707.12
Aluminum Alloy Structural Plate for Pipe, Pipe Arches, & Arches

Plates and the bolts and nuts for connecting plates shall meet the requirements of AASHTO M 219.

707.13
Aluminum-Coated Type 2 Corrugated Steel Pipe & Pipe Arches

(a) Pipe and coupling bands shall meet the requirements of AASHTO M 36 except that they shall be made from material meeting the requirements of AASHTO M 274.

(b) Special sections such as elbows, tees, and wyes shall be the same thickness as the conduit to which they are joined and shall meet the applicable requirements of AASHTO M 36 and M 274.

707.14
Aluminum-Zinc-Alloy-Coated Corrugated Pipe and Pipe Arches

(a) Pipe and coupling bands shall meet the requirements of AASHTO M 36 except that they shall be made from material meeting the requirements of AASHTO M 289.

(b) Special sections such as elbows, tees, and wyes shall be the same thickness as the conduit to which they are joined and shall meet the applicable requirements of AASHTO M 36 and M 289.

707.15
Bituminous-Coated Polymeric-Precoated Steel Pipe, Pipe Arches, & Underdrains

These conduits and their coupling bands shall meet the requirements of AASHTO M 190. The coating shall be Type A, C, or D, or invert paved only, or 100 percent paved only. Pipe shall be made from material conforming to AASHTO M 245 Polymeric Precoated Steel Pipe.

Section 708 - Paints

708.01
(Reserved)

708.02
Paint for Timber Structures

Paint for timber structures shall be white or as SHOWN ON THE DRAWINGS and shall meet the requirements of AASHTO M 70, Type I, Class B. The paint as specified is intended for use in covering previously painted surfaces. When applied to unpainted timber, turpentine and linseed oil shall be added as required by the character of the surface in an amount not to exceed 1 pint each per gallon of the paint.

708.03
Paint for Steel Structures

(a) General. All paint furnished shall be shipped in strong, substantial containers, plainly marked with the name, weight, and volume of paint content, together with the color, formula, and the name and address of the manufacturer. Paint systems shall be of the type SHOWN ON THE DRAWINGS. Except as otherwise required in the cited specifications, all paint shall meet the following requirements:

(1) The paint shall not show excessive settling in a freshly opened full can and shall easily be redispersed with a paddle to a smooth, homogeneous state. The paint shall show no curdling, livering, caking, or color separation and shall be free from lumps and skins.

(2) The paint as received shall brush easily, possess good leveling properties, and show no running or sagging tendencies when applied to smooth steel vertical surfaces.

(3) The paint shall not form a skin within 48 hours in a three-quarters filled closed container.

(4) The paint shall dry to a smooth uniform finish, free from roughness, grit, unevenness, and other surface imperfections. It shall show no streaking or separation when flowed on clean glass.

(5) The paint shall show no thickening, curdling, gelling, or hard caking after 6 months storage in a full, tightly covered container at a temperature of 70 °F.

(b) System 1--Vinyl Paint System.

(1) Vinyl wash primer shall meet the requirements of MIL-P-15328.

(2) Vinyl intermediate coat shall meet the requirements of MIL-P-15929, MIL-P-15930, or SSPC-Paint-8 or -9.

(3) Third and fourth coats shall be the same as the intermediate coat.

(4) Final coat shall be the same as the intermediate coat or SSPC-Paint-8 or -9 or Fed. Spec.-TT-P-615 to obtain the specified finish color.

(c) System 2--Epoxy-Polyamide Paint System

(1) Primer coat shall meet the requirements of MIL P-24441, Formula 150 and the color as specified.

(2) Intermediate coat and third coat shall meet the requirements of MIL-P-24441, using contrasting color sequences.

(3) Final coat shall meet the requirements of SSPC-Paint-8 or -9 or Fed. Spec.-TT-P-615 to obtain the specified final coat, and shall be applied in accordance with the recommendations of the manufacturer of the undercoat. The entire paint system shall be supplied by the same manufacturer.

(d) System 3--Inorganic Zinc Silicate System.

(1) Primer coat shall be an inorganic zinc silicate paint of the two-component self-curing type that, when mixed, cures without the use of a separate curing solution, and shall have the properties described herein.

a. Pigment. The zinc pigment component shall meet the requirements of ASTM D 520 for Type II. The average particle size of the zinc powder shall not exceed 10 microns as determined by the Fisher sub-sieve sizer.

b. Vehicle. The vehicle component shall consist primarily of an alkyd silicate in an appropriate alcohol solvent. Total solids, by content, shall be determined by drying the sample to a constant weight at 100 °C.

c. Mixed Paint. Mixed paint shall meet the following requirements:

1. The zinc portion shall be at least 75 percent by weight of the total solids of the dried coating.

2. The total solids, when heated at 100 °C for 3 hours, shall be not less than 72 percent by weight.

3. The paint shall tolerate up to 1 percent water contamination without gelation.

4. The usable pot life of the mixed paint shall be not less than 12 hours at 77 °F. There shall be no hard settling that cannot be easily redispersed during this period.

5. The inorganic zinc coating shall be formulated to produce a distinct contrast in color with blast-cleaned metal surfaces and with the topcoat.

d. Resistance Tests. Test panels of steel meeting the requirements of ASTM D 609, having dimensions of 2 by 5 by 0.125 inches, shall be prepared by blast cleaning leaving all surfaces with a dense and uniform anchor pattern of not less than 1.5 mils, measured with an approved surface profile comparator or Testx-presse tape. A 3- to 4-mil coating (dry thickness) shall then be applied to the test panels in accordance with the manufacturer's current printed instruction. The coating shall be cured as recommended by the manufacturer. Each of the following tests shall be performed on a minimum of three panels. The material will not be accepted if any individual test panel fails any of the following tests:

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.03

1. Fresh Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch legs and shall be immersed in fresh tap water at 75 °F, plus or minus five degrees. The panels shall show no rusting, blistering, or softening when examined after 30 days.

2. Salt Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch legs and immersed in five percent sodium chloride at 75 °F, plus or minus five degrees and examined at 7, 14, and 30 days. The sodium chloride solution shall be replaced with fresh solution after each examination.

3. Weathering Resistance. Panels shall be tested in accordance with ASTM G 23, Type D. The panels shall be placed on test at the beginning of the wet cycle. After 1,000 hours of continuous exposure, the coating shall show no rusting, loss of adhesion to the steel test panel, or blistering.

4. Weather and Salt Fog Resistance. Panels shall be tested in the weatherometer as specified in Part 3 above for 300 hours. After this period the panels shall be removed and scribed with an X of at least 2-inch legs down to base metal. The test panels shall then be tested in accordance with ASTM B 117. After 1,000 hours of continuous exposure, the coating shall show no loss of bond, nor shall it show rusting or blistering beyond 1/16 inch from the center of the scribe mark.

5. Resistance to Elevated Temperatures and Thermal Shock. Panels shall be exposed to a temperature of 500 °F for 1 hour, then quenched immediately in water 65 °F plus or minus five degrees. Panels subjected to this test shall show no blistering or flaking of the coating.

6. Adhesion Panels. Adhesion panels shall be tested in accordance with ASTM D 3359 and shall attain a rating of three or greater.

7. Mud Cracking Resistance. The coating, when applied to test panels as provided above, to a 5- or 6-mil dry film thickness shall not show mud cracking when viewed under 10 power magnification.

e. Manufacturer and Brand Name Approved for Inorganic Zinc Primer. Prior to approval and use of inorganic zinc, the contractor shall submit in triplicate to the Engineer a certified test report from an approved independent testing laboratory showing specific test results meeting all quantitative and resistance test requirements of these specifications. The certified test report shall also contain the exact ratio, by weight, of the pigment component to the vehicle component of the paint used for the tests, the lot tested, the manufacturer's name, brand name of paint, and date of manufacture. Upon approval by the Engineer of this certified test report, further resistance tests will not be required, except as hereinafter noted, of that manufacturer for that brand name of paint for a period of 2 years from the date of test completion. New certified test results shall be submitted any time the manufacturing process or the paint formulation is changed, and may be required by the Engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements specified.

(2) Intermediate coat shall be applied as recommended by the manufacturer in a single application employing multiple spray passes. The color of the intermediate coat shall contrast with both the primer and final coat. The tie coat shall shall meet the requirements of MIL-P-15328, or MIL-P-24441, Formula 150.

(3) Final coat shall be applied as recommended by the manufacturer in a single application employing multiple spray passes. The final coat shall meet the requirements of SSPC-PC-8 or -9. For MIL-P-24441 intermediate coat see System 2, Final Coat.

The contractor shall submit final coat color chips for approval of color by the Engineer.

(e) System 4--Alkyd-Oil Basic Lead Silico-Chromate System.

(1) Primer coat shall meet the requirements of Fed. Spec.-TT-P-615 or AASHTO M 229.

(2) Intermediate coat shall be the same as the prime coat but tinted to contrast with both the prime coat and the final coat.

(3) The contractor shall submit final coat color chips for approval of the color by the Engineer.

(f) System 5--Organic Zinc-Rich Paint System.

(1) Prime coat shall meet the following requirements:

a. Description. This specification covers a one-package, thermoplastic, organic zinc-rich primer whose mechanism of drying is that of solvent release. It is intended for use only on blast-cleaned open steel structures exposed to the air.

b. Composition. The composition of the organic zinc-rich paint is specified in the following tables.

The average particle size of the pigment shall not exceed nine microns as determined by the Fisher Sub-Sieve Sizer. The red iron oxide must first be ground into a portion of the vehicle to provide a Hegman grind sufficient to produce the specified color of the finished paint.

The necessary additives to prevent gas formation in the containers during storage shall be incorporated into the formulated paint.

c. Infrared Characteristic Curve of Primer Vehicle. When dried upon a potassium bromide disc, a film of the primer shall have infrared absorption maximums at the same wavelengths and to the same relative degree as that shown by the curve on file.

The composition of the extracted zinc dust pigment shall match the X-ray diffraction curve on file.

Table 708-1.--Pigment ingredients (62.3 percent of composition weight, minimum).

Ingredient	Specification	Parts by Weight of Pigment	
		Type I Red Tint	Type II Gray Tint
Zinc Dust	ASTM D 520	95.0 min.	95.0 min.
Red Iron Oxide[a]	—	1.5 max.	—
Zinc Oxide	ASTM D 3280	—	1.5 max.
Thixotropes and Additives	—	3.5 max.	3.5 max.

[a] Fe$_2$O$_3$ 98.5 percent minimum; oil absorption, 21; fineness through 325 mesh screen, 99 percent minimum; and specific gravity, 5.15.

Table 708-2.--Vehicle ingredients (37.7 percent of composition weight, maximum).

Ingredients	Specification	Parts by Weight of Vehicle
Polyaryl Ether[a]	____________	19.0
Ethylene Glycol Monoethyl Ether Acetate	MIL-E-7125	66.8
Toluene	Fed. Spec.-TT-T-548	14.2

[a] A polyhydroxy polyalkaryl polyether of the following properties:

Specific gravity	1.18
Viscosity of 49 percent solids in methyl ethyl ketone, Brookfield RVF, 20 rpm No. 5 spindle	5,500 to 7,700 cps
Reduced viscosity (0.2 g/100 ml. dimetheylformamide)	0.4 to 0.6
Ultimate tensile strength	9,000 to 9,500 psi
Ultimate tensile elongation	50 to 100 percent
Softening temperature	212 °F
Bulking value	9.83 lbs. per gal.

d. Characteristics of Paint:

The paint shall, in addition to the preceding composition, meet the following requirements:

Volatiles at 105 °C, percent by weight	28-32
Weight per gallon, pounds	17.2-18.0
Viscosity, KU at 77 °F	100-120
Metallic zinc, percent by weight of extracted pigment by Federal Test Method Standard No. 141, Method 7221	90.2 min.
Dry time at 77°F, 50 percent relative humidity, 6-mil wet thickness:	
Set to touch, hours	3/4 max.
Dry hard, hours	5 max.
Storage life, years	1 min.

e. Properties of Cured Coating. When applied to a plate glass panel with a 6-mil gap clearance doctor blade and cured for 15 days at 77 °F plus or minus five degrees, and 50 percent relative humidity, plus or minus 5 percent, the coating shall have the following properties:

Pencil hardness	B min.
Color (for Type I only)	Not lighter than Federal Standard Color 31575

When applied by air or airless spray to a minimum dry film thickness of 1.5 mils on blast-cleaned steel having an anchor profile pattern of 1.0 to 1.5 mils, the mixed paint shall completely wet the surface of the steel with no evidence of dry spray particles or sagging.

When applied to a wet film thickness of 6 mils on a metal panel corresponding to Fed. Spec.-QQ-S-698, the panel being previously cleaned by blast cleaning to produce a 1.0- to 1.5-mil anchor pattern, and cured for 15 days at a relative humdity of 50, plus or minus 5 percent, and tested in accordance with the Conical Mandril Test, Federal Test Method Standard No. 141, Method 6222, there shall be no loosening of the film above the point of the longest continuous crack.

When a steel panel is blast cleaned to white metal and coated with 3- to 4-mils dry film thickness of this coating and cured for 15 days at 75 °F plus or minus two degrees and 50 percent relative humidity plus or minus 5 and diagonally scribed to expose base steel, there shall be no underfilm corrosion on the surface of the panel extending beyond the scribed lines after 1,000 hours when tested in accordance with ASTM B 117.

Prior to use, the paint shall be thinned with not more than one part of thinner to four parts of paint using a power-agitated stirrer. The thinner shall consist of a mixture of 82 percent by volume of ethylene glycol monoethyl ether acetate and 18 percent by volume of toluene.

(2) Intermediate coat shall be the same as the prime coat tinted to contrast with both the prime coat and the vinyl wash coat.

(3) Vinyl wash tie coat shall meet the requirements of MIL-P-15328.

(4) Final coat shall meet the requirements of SSPC-Paint-8 or -9, or Fed. Spec.-TT-P-615 with the color as specified.

(g) Sampling and Testing. Unless otherwise specified, sampling will be performed in accordance with Federal Test Method Standard No. 141, Method 1022.

The paint will be tested in accordance with methods of Federal Test Method Standard No. 141, as follows:

Test	Method # 141	ASTM Method
Percentage of Pigment	4021	--
Isolation of Vehicle	4032	D 2698
Nonvolatile in Vehicle	4053[a]	--
Phthalic Anhydride		D 563
Uncombined Water	4081	D 1364
Consistency: Krebs-Stormer		D 562
Coarse Particles and Skins		D 185
Weight per Gallon		D 1465
Set to Touch Time	4061	--
Condition in Container	3011	--
Brushing Properties	2141, 4321	--
Skinning	4141	--
Rosin and Resin Derivatives	--	D 1542
Storage Stability	4142	--
Dry Through Time	4061	--
Fineness of Grind		D 1210

[a] A gravity convection oven may be used to determine the nonvolatile content of the supercentrifuged vehicle if the procedure outlined in ASTM D 2369 is modified as follows: Weigh accurately from 0.8 to 1.2 gram of sample (by difference), heat for one hour, cool and weigh. Use the lower value to calculate the percentage of nonvolatile matter.

Section 709 - Reinforcing Steel & Wire Rope

709.01
Reinforcing Steel

Reinforcing steel shall meet the following requirements:

(a) Deformed and plain billet steel bars for concrete reinforcement . . . . AASHTO M 31

(b) Low-alloy steel deformed bars for concrete reinforcement . . . . ASTM A 706

(c) Metal chair supports. All supports not covered by at least 1/2 inch of concrete shall meet one of the following:

  (1) Hot-dipped galvanized . . . . AASHTO M 232

  (2) Stainless steel . . . . ASTM A 493, Type 430

  (3) Plastic coated . . . . As approved by Engineer

(d) Fabricated steel bar or rod mats for concrete reinforcement . . . . AASHTO M 54

(e) Welded steel wire fabric for concrete reinforcement . . . . AASHTO M 55

(f) Welded deformed steel wire fabric for concrete reinforcement . . . . AASHTO M 221

(g) Dowel and tie bars . . . . AASHTO M 31

(h) Epoxy coated reinforcing bars . . . . AASHTO M 284

(i) Galvanized reinforcing bars . . . . ASTM A 767

Tie bars shall be deformed bars. Dowel bars shall be plain round bars, and shall be free from burring or other deformation restricting slippage in the concrete. At least one-half the length of each dowel bar shall be painted with one coat of approved tar paint before delivery to the work site.

The sleeves for dowel bars shall be metal of an approved design to cover 2 inches, plus or minus 1/4 inch, of the dowel. The sleeve shall have a closed end with a stop to hold the end of the sleeve at least 1 inch from the end of the dowel bar. Sleeves shall be designed so they will not collapse during construction.

709.02
Wire Rope or Wire Cable

The wire rope or wire cable shall meet the requirements of AASHTO M 30.

709.03
Prestressing Reinforcing Steel

Prestressing reinforcing steel shall be high-tensile wire meeting the requirements of AASHTO M 204, high-tensile wire strand or rope meeting the requirements of AASHTO M 203, or high-tensile alloy bars cold stretched to a minimum of 130,000 psi. The resultant physical properties shall be as follows:

Minimum ultimate tensile strength . . . . . . 145,000 psi followed by stress relieving

Minimum yield strength, measured by the 0.7 percent extension under load method shall not be less than . . . . 130,000 psi

Minimum modulus of elasticity . . . . 25,000,000 psi

Minimum elongation in 20 bar diameters after rupture . . 4 percent

Diameter tolerance . . . . +0.03 inch
-0.01 inch

Section 710 - Fence & Guardrail

710.01 Barbed Wire

Galvanized barbed wire shall meet the requirements of ASTM A 121. Aluminum coated barbed wire shall meet the requirements of ASTM A 585, with Type I (Aluminum Coated) or Type II (Aluminum Alloy) barbs at the option of the manufacturer.

710.02 Woven Wire

Galvanized woven wire fence shall meet the requirements of ASTM A 116. Aluminum coated woven wire fence shall meet the requirements of ASTM A 584.

710.03 Chain Link Fence

Chain link fabric and the required fittings and hardware shall meet the requirements of AASHTO M 181. Galvanized coiled spring steel tension wire shall be 7 gauge, meeting the requirements of ASTM A 641, hard temper with Class 3 coating.

710.04 Metal Beam Rail

Steel rail elements shall be corrugated sheet steel beams meeting the requirements of AASHTO M 180 for the class and type SHOWN ON THE DRAWINGS.

710.05 Timber Rail

The timber rail shall be cut from dry, well-seasoned, and dressed timber stock, meeting the requirements of AASHTO M 168 for the grade and species SHOWN ON THE DRAWINGS.

Preservative treatment shall meet the requirements of Subsection 716.03.

Rustic rails shall be straight, sound, and free of injurious defects and shall be cut from live trees not less than 30 days but not more than 1 year before use. They shall be stripped of bark before seasoning or shall be stored under water. Immediately before the logs are used in the work, all knots and projections shall be trimmed smooth and, if water cured, all bark shall be peeled. Slight curvature or "wind" that will give a pleasing appearance to the structure will be permitted.

710.06 Fence Posts

Wood post details and dimensions shall be as SHOWN ON THE DRAWINGS. All wood posts shall be of sound, seasoned wood, peeled and with ends cut as SHOWN ON THE DRAWINGS. The posts shall be straight and all knots trimmed flush with the surface. Where treated posts are called for, the kind and type of treatment shall meet the requirements SHOWN ON THE DRAWINGS. The requirements for peeling may be omitted for red cedar posts or bracing.

All dimension timber and lumber required for fences or gates shall be sound, straight, and reasonably free from knots, splits, and shakes. The species and grades shall be as SHOWN ON THE DRAWINGS and shall be dressed and finished on four sides.

Concrete posts shall be made of concrete meeting the requirements of Section 602, Method A or B. Steel reinforcement, as SHOWN ON THE DRAWINGS, shall meet the requirements of Section 709.

Steel posts for line-type fencing shall be manufactured in accordance with ASTM A 702 and galvanized in accordance with AASHTO M 111 (ASTM A 123), except that tubular steel posts shall be galvanized in accordance with ASTM A 120. Fittings, hardware, and other appurtenances shall be galvanized in accordance with ASTM A 120, by current standard practice, and be of standard commercial grade. Weathering steel posts shall meet the requirements of AASHTO M 222.

Aluminum alloy posts shall meet the requirements of AASHTO M 181.

710.07 Guardrail Posts & Blocks

Railing posts shall be of wood or steel as SHOWN ON THE DRAWINGS and shall meet the following requirements:

(a) Wood posts and blocks shall be fabricated from timber species meeting the requirements of AASHTO M 168. The species, diameter or section, length, and treatment shall be as SHOWN ON THE DRAWINGS. Treated posts shall be fabricated or framed before treatment. Timber preservatives shall meet the requirements of Subsection 716.03.

(b) Steel posts shall be copper bearing steel of the section, length, and grade as SHOWN ON THE DRAWINGS. Steel shall meet the requirements of AASHTO M 183 unless otherwise SHOWN ON THE DRAWINGS. The posts shall be galvanized, shop painted, or left bare as SHOWN ON THE DRAWINGS.

(c) Box beam posts shall be of the section and length SHOWN ON THE DRAWINGS. Posts, base plates, splice plates, anchor plates, and plate material for soil-bearing plates and rail connections shall meet the requirements of AASHTO M 183 unless otherwise SHOWN ON THE DRAWINGS and shall be galvanized in accordance with AASHTO M 111.

710.08 Guardrail Hardware

All bolts, nuts, washers, and other fittings for beam-type guardrail shall be steel and of a quality adequate to develop the specified strength of rail splices. All fittings shall be galvanized to meet the requirements of AASHTO M 232.

All bolts, nuts, and washers for metal beam rail shall meet the requirements of AASHTO M 180. Nuts shall not be tapped oversize more than 1/32 inch. Nuts, bolts, and washers for box beam rail shall be as SHOWN ON THE DRAWINGS.

(a) Interchangeability. Bolts, nuts, and other fittings shall be interchangeable with similar parts.

(b) Qualifying and Duplication Tests. The bolts, nuts, and other fittings shall be subjected to qualifying tests to determine conformance with specifications. At least one test will be required on the materials furnished by each manufacturer of the materials. Materials required by the Forest Service for tests shall be furnished without cost.

Once the fittings produced by a manufacturer have qualified under test, the similar products of this manufacturer will be subject to subsequent inspection and testing at any time to ensure that the materials are duplicates of those tested. Subsequent inspections and testing may consist of visual inspection, tests on the physical properties of the metal, tests of the galvanizing, and verification of design. When subsequent inspection and testing provide reason to question the duplication, the contractor shall furnish fittings for a new qualifying test prior to use of the materials.

Cable and fittings for anchors shall meet the requirements of AASHTO M 30 for Type II cable.

Rods for anchors shall meet the requirements of AASHTO M 183. All other fittings shall develop the strength of the rod.

All fittings and rods shall be galvanized in accordance with AASHTO M 111.

710.09
Box Beam Rail

Steel beam rail elements shall meet the requirements of ASTM A 500, Grade B, or ASTM A 501 and shall be galvanized after fabrication in accordance with AASHTO M 111, except when corrosion-resistant steel rail elements are specified. In this case, rail elements shall be made of steel meeting the dimensional and mechanical requirements of ASTM A 500, Grade B, or ASTM A 501 and having an atmospheric corrosion-resistance approximately two times that of carbon structural steel with copper, and shall not be painted or galvanized. Posts shall meet the requirements of Subsection 710.07 and hardware of Subsection 710.08.

Section 711 - Concrete Curing Materials & Admixtures

711.01
Curing Materials

Curing materials shall meet the following requirements:

(a) Burlap cloth made from jute or kenaf . . . . . . AASHTO M 182

(b) Sheet materials for curing concrete . . . . . . AASHTO M 171

(c) Liquid membrane-forming compounds for curing concrete . . . . AASHTO M 148

711.02
Air-Entraining Admixtures

Air-entraining admixtures shall meet the requirements of AASHTO M 154.

711.03
Chemical Admixtures

Water-reducing, set-retarding, and set-accelerating admixtures shall meet the requirements of AASHTO M 194.

711.04
Carbon Black

Emulsified carbon black shall be a uniform colloidal dispersion of standard carbon gas black in a liquid medium. At least 25 percent by weight shall be carbon black. The product shall be free of lampblack, mineral black, silicas, asbestine, talc, boneblack, or other fillers. It shall be free of substances deleterious to the strength, durability, or appearance of concrete. Addition of carbon black, at the specified rate, to concrete of the proportions and air content to be used in the work shall not reduce the compressive strength by more than 5 percent. Emulsified carbon black shall be so finely processed and dispersed that when 1 part is stirred into 10 parts of water, and the mixture left standing without agitation for 72 hours, the resulting liquid will remain uniformly colored from top to bottom. The emulsified carbon black shall be delivered on the job in sealed containers plainly marked with the manufacturer's name and address, together with the trade name of the product and a statement indicating whether or not addition of an air-entraining admixture to the carbon black has been made.

Section 712 - Miscellaneous

712.01
Water

(a) Water used in mixing, curing, or other applications shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, or any other substance injurious to the finished product. Water shall be tested in accordance with and shall meet the requirements of AASHTO T 26.

(b) Water known to be of potable quality may be used without further testing.

712.02
Calcium Chloride & Sodium Chloride

Calcium chloride shall meet the requirements of AASHTO M 144.

Sodium chloride shall meet the requirements of AASHTO M 143.

712.03
Hydrated Lime

Hydrated lime shall meet the requirements of ASTM C 207, Type N.

712.04
Stone Curbing

(a) Stone Curb. The stone for stone curb items shall meet the requirements for size and shape specified and shall also meet the following requirements:

Stone curb shall be approved limestone, sandstone, or granite from acceptable sources. Stone material shall be as SHOWN ON THE DRAWINGS. The exposed faces of stone curb shall be free from drill holes.

All vertical stone curb shall have a top surface sawed or pointed to an approximate true plane with no depression or projection on that surface of over 1/4 inch. The front and back arris lines shall be pitched straight and true. There shall be no projection or depression on the back surface that would exceed a batter of 1 inch horizontal on 3 inches vertical.

The front exposed face vertical stone curb shall be sawed, pointed, or smooth quarry split, as SHOWN ON THE DRAWINGS, and shall be formed to an approximately true plane. The remaining face distance shall have no projections or depressions greater than 1 inch from the plane of the exposed face noted above.

The ends of vertical stone curb shall be square with the planes of the top, back, and face finished so that when the sections are placed end to end as closely as possible, no space more than 1/2 inch shall show in the joint for the full width of the top surface and for the entire exposed front face. The remainder of the end may break back no more than 4 inches from the plane of the joint. The joints of circular or curved stone curb shall be cut on radial lines.

The minimum length of any segment of vertical stone curb shall be as SHOWN ON THE DRAWINGS. When required for driveways, crossings, closures, or for other reasons, a depressed or modified section of curb as SHOWN ON THE DRAWINGS shall be furnished by the contractor.

(b) Slope Stone Curb. Slope stone curb shall meet the requirements of stone curb except as follows:

The maximum allowable projection or depression on a horizontal top surface shall be 1/2 inch; on other exposed faces the maximum allowable projection or depression shall be 1 inch.

For unexposed surfaces, the maximum allowable projection or depression from a true plane on a 2-foot length shall be 3 inches.

The maximum allowable space showing on exposed faces between adjacent segments of slope stone curb shall be 3/4 inch.

The minimum length of any segment of slope stone curb shall be 2 feet.

712.05 Precast Concrete Curbing

Precast concrete curbing shall consist of precast Portland cement concrete curb units constructed to the lengths, shapes, and other details SHOWN ON THE DRAWINGS. Steel reinforcement shall meet the requirements of Subsection 709.01. Concrete shall attain a minimum 28-day compressive strength of 3,000 psi as determined in accordance with AASHTO T 22.

When required for driveways, crossing, closures, or for other reasons, a depressed or modified section or curb as SHOWN ON THE DRAWINGS shall be furnished by the contractor.

712.06 Precast Concrete Units

Precast concrete units shall be cast in substantial permanent steel forms. The structural concrete used shall attain a minimum 28-day compressive strength of 3,000 psi as determined in accordance with AASHTO T 22. Air-entrained concrete shall have an air content of 6 percent plus or minus 2 percent by volume. The precast units shall be cured in accordance with AASHTO M 170. Water absorption of individual cores taken from such units when tested in accordance with AASHTO T 33 shall not exceed 8 percent. Additicnal reinforcement shall be provided as necessary to provide for handling of the precast units.

A sufficient number of cylinders shall be cast from the concrete for each unit to permit compression tests at 7, 14, and 28 days, and to allow for at least two cylinders for each test. If the strength requirement is met at 7 or 14 days, the units will be certified for use from the date of casting. If the strength requirement is not met at 28 days, all units made from that batch or load will be rejected.

Cracks in units, honeycombed or patched areas in excess of 30 square inches, excessive water absorption, and failure to meet strength requirements will be cause for rejection. Precast reinforced concrete manhole risers and tops shall meet the requirements of AASHTO M 199.

712.07 Frames, Gratings, Covers, & Ladder Rungs

Metal units shall be as SHOWN ON THE DRAWINGS and shall meet the following requirements:

(a) Metal gratings and covers that are to rest on frames shall bear on them evenly. They shall be assembled before shipment and marked so the same pieces may be reassembled readily in the same position when installed. Inaccuracy of bearings shall be corrected by machining, if necessary. A frame and the grating or cover to be used with it shall constitute one pair.

(b) All castings shall be uniformly coated with asphalt varnish meeting the requirements of Fed. Spec.-TT-V-51.

(c) Gray iron castings shall meet the requirements of AASHTO M 105. Strength class shall be as SHOWN ON THE DRAWINGS.

(d) Carbon-steel castings shall meet the requirements of AASHTO M 103. Grade shall be as SHOWN ON THE DRAWINGS.

(e) Structural steel shall meet the requirements of AASHTO M 183 or ASTM A 283, Grade D or better.

(f) Galvanizing, when specified for these units, shall meet the requirements of AASHTO M 111.

(g) Aluminum alloy ladder rung material shall meet the requirements of ASTM B 221, alloy 6061-T6 or 6005-T5.

712.08 Corrugated Metal Units

The units shall be as SHOWN ON THE DRAWINGS and the metals shall meet the requirements of AASHTO M 36 and M 196. Coating, when specified, shall meet the requirements of AASHTO M 190, Type A, or M 245 as SHOWN ON THE DRAWINGS, except that the Engineer may waive the imperviousness test if no separation of the coating from metal is observed.

712.09
Lignin Sulfonate

Lignin sulfonate shall be the residue produced by the acid-sulfite pulping of wood. The base cation shall be ammonium, calcium, or sodium. The lignin sulfonate shall be supplied as a water solution.

The lignin sulfonate shall be miscible with an equal volume of water. The undiluted material shall meet the following requirements:

pH (AASHTO T 200)	4.5 minimum
Viscosity at 77 °F (AASHTO T 202)	20.5 poise maximum
Total Solids (TAPPI T 629-M 53)	48 percent minimum

The solids shall meet the following requirements:

Lignin Sulfonate	50 percent minimum
Reducing Sugars	25 percent maximum

Temperature. The temperature of the material from the time it is loaded until it is applied on the road shall not exceed 140 °F. The temperature of the material at application shall be between 40 °F and 140 °F.

Certification. When each load of lignin sulfonate is delivered, the contractor shall furnish the Engineer with a completed Certificate of Compliance conforming to the format shown in figure 712-1. A separate Certificate of Compliance will not be required if the Bill of Lading contains the following information.

CONSIGNEE______________________ DESTINATION________________

DATE___________________________ NET WEIGHT_________________
IDENTIFICATION (TRUCK NO., CAR NO., ETC.)

BASED CATION___________________ BRAND NAME_________________

This shipment of lignin sulfonate identified above and covered by this Certificate of Compliance complies with the Forest Service Standard Specifications as modified by SPECIAL PROJECT SPECIFICATIONS applicable to this project.

PRODUCER___________________

SIGNED_____________________
Producer's Representative

Figure 712-1.--Sample Certificate of Compliance.

712.10
Epoxy Resin Adhesives

Epoxy resin adhesives shall meet the requirements of AASHTO M 234 and M 235. Class I adhesives shall be used to bond fresh concrete to cured concrete. Class II adhesives shall be used to bond cured concrete to cured concrete and as a binder in epoxy resin concrete and mortar to repair defects in cured concrete. Class II adhesives, to be used in exposed epoxy mortar or epoxy concrete, shall be a uniform, concrete gray color when thoroughly mixed. Manufacturer's certification shall be furnished prior to its use in the work.

712.11
Magnesium Chloride

Magnesium chloride shall be a brine consisting of water and magnesium chloride.

(a) Chemical Analysis.* The chemical analysis shall meet the following requirements:

Chemical	Percent by Weight of Brine
Magnesium	7.0 minimum
Chloride	20.0 minimum
Sulfate	4.3 maximum
Nitrate	5.0 maximum

The pH shall be between 4.5 and 10.0. The solids shall be at least 30 percent by weight of the brine.

(*Copy of test procedures available upon request from USDA Forest Service, Pleasant Hill Engineering Center, 2245 Morello Avenue, Pleasant Hill, CA 94523.)

(b) Temperature. The temperature of the material shall be 40 °F or above when it is applied.

(c) Certification. When each load of magnesium chloride is delivered, the contractor shall furnish the Engineer with a completed Certificate of Compliance conforming to the format as shown in figure 712-2. A separate Certificate of Compliance will not be required if the Bill of Lading contains the required information.

CONSIGNEE ____________________ DESTINATION ____________________

DATE ____________________ NET WEIGHT ____________________

IDENTIFICATION ____________________ SOURCE ____________________
(Truck No., Car No., Etc.) (Mfg. & Location)

This shipment of magnesium chloride identified above and covered by this Certificate of Compliance complies with Forest Service Standard Specifications as modified by SPECIAL PROJECT SPECIFICATIONS applicable to this project.

PRODUCER ____________________

SIGNED ____________________
Producer's Representative

Figure 712-2.--Sample Certificate of Compliance.

712.12 Bonding Agents

Bonding agents shall meet the requirements SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

712.13 Delineators

The delineator reflector shall be Type 1 or Type 2 as SHOWN ON THE DRAWINGS. The reflectors shall be amber or crystal and ready for mounting.

The delineator element shall consist of a sealed optical system complete with aluminum housing and assembly hardware as SHOWN ON THE DRAWINGS. The post-mounting hardware shall consist of all bolts, nuts, plain or lock washers, fastening plates, and brackets as SHOWN ON THE DRAWINGS.

712.14 Fly Ash & Pozzolan Cement Substitutes

Fly ash and raw or calcined pozzolan, for use with Portland cement, shall conform to the requirements of ASTM C 618, either Class F or Class C, except the maximum loss at ignition for either Class shall be 1.5 percent, unless otherwise specified in the contract.

The use of fly ash produced by plants, which utilizes compounds of sodium, ammonia, or sulfur, such as soda ash, to control stack emissions, shall be prohibited for use in structural concrete.

The contractor shall furnish certificates and test results substantiating that the material conforms to the above requirements.

Section 713 - Roadside Improvement Materials

713.01 Topsoil

Topsoil shall consist of loose, friable, sandy loam, free of admixture of subsoil, refuse, stumps, roots, rocks, brush, weeds, or other material that would be detrimental to the development of vegetative growth. Topsoil, as used herein, shall mean that portion of the soil profile defined technically as the "A" horizon by the Soil Science Society of America.

Topsoil shall have a grading analysis as follows:

Sieve Designation	Percentage by Weight Passing Square Mesh Sieve
1"	100
1/4"	97-100
No. 10	80-100

The minimum and maximum pH values shall be 5 and 8, respectively.

Topsoil shall contain a minimum of 3 percent and a maximum of 20 percent organic matter as determined by loss on ignition of samples oven dried to constant weight at 212 °F.

Topsoil shall consist of the following particle sizes:

Material	Size	Percent in Topsoil	
		Min.	Max.
Sand	0.075-2 mm	20	75
Silt	0.002-0.075 mm	10	60
Clay	0.002 mm or less	5	30

Prior to stripping, topsoil shall have demonstrated by the occurrence upon it of healthy crops, grass, or other plant growth, that it is of good quality and reasonably free draining. All testing will be at the expense of the Government. The contractor will be reimbursed for materials provided to improve the pH, organic matter, or other quality of the onsite topsoil when requested by the Engineer.

713.02 Agricultural Limestone

Agricultural limestone shall be a calcic or dolomitic ground limestone containing not less than 85 percent of total (calcium and magnesium) carbonates.

Rates of application shall be specified in the SPECIAL PROJECT SPECIFICATIONS.

Limestone shall meet the following sieve analysis: at least 40 percent passing a No. 100 sieve and at least 95 percent passing a No. 8 sieve.

Granulated slag or other approved natural sources of lime may be used, provided the application rate is adjusted to equal the total neutralizing power of the specified ground limestone.

713.03 Fertilizer

Fertilizer shall be a standard commercial grade and provide the minimum percentage of available nutrients specified in the SPECIAL PROJECT SPECIFICATIONS.

Fertilizer shall be furnished in new, clean, and sealed containers with the name, weight, and guaranteed analysis of contents clearly marked. Fertilizer failing to meet the specified analysis may be used providing sufficient materials are applied to supply the specified nutrients without additional cost to the Government.

A liquid form of fertilizer containing the minimum percentage of available nutrients may be used.

713.04
Seed

The kinds of grass, legume, and cover-crop seed furnished shall be those stipulated in the SPECIAL PROJECT SPECIFICATIONS. Seed shall meet the requirements of Federal Specification-JJJ-S-181.

Seed shall be furnished separately or in mixture in standard containers with (1) seed name; (2) lot number; (3) net weight; (4) percentages of purity and of germination (in case of legumes, percentage of germination to include hard seed); and (5) percentage of maximum weed seed content clearly marked for each kind of seed. Unless otherwise stated in the SPECIAL PROJECT SPECIFICATIONS, the contractor shall furnish the Engineer duplicate signed copies of a statement by the vendor, certifying that each lot of seed has been tested by a recognized laboratory for seed testing within 6 months of date of delivery. This statement shall include (1) name and address of laboratory, (2) date of test, (3) lot number for each kind of seed, and (4) results of tests as to name, percentages of purity and of germination, and percentage of weed content for each kind of seed furnished, and, in case of a mixture, the proportions of each kind of seed. Legume seed shall be inoculated with approved cultures in accordance with the instructions of the manufacturer.

713.05
Mulch

(a) Wood Chips. Wood chips shall be obtained from green hardwood. They shall be 1/8 inch nominal thickness with 50 percent having an area of not less than 1 square inch, and not more than 6 square inches. All wood chip mulch shall be free of leaves, twigs, shavings, bark, or materials injurious to plant growth. Wood chips from elm trees will not be used when State or Federal regulation prohibits such use, or when the trees are diseased.

(b) Straw. Straw for mulching shall be from grain crops that are free from noxious weeds, mold, or other objectionable material. Straw mulch shall be in an air-dry condition and suitable for placing with mulch blower equipment.

(c) Hay. Grass hay shall be of approved herbaceous mowings, free of noxious weeds, mold, or other objectionable material. Grass hay shall be in an air-dry condition and suitable for placing with mulch blower equipment.

(d) Wood Cellulose Fiber. Natural wood cellulose fiber mulch shall be produced from clean, whole-wood chips and have the property of dispersing readily in water. The material shall contain no weed seed and shall be heat-processed to eliminate factors that inhibit growth and germination. The material shall have no toxic effect when combined with seed or other materials and shall have the following physical and chemical properties:

Moisture Content	7-13%
Organic Matter (Oven-dried Basis)	99.1% minimum
Ash Content	0.9% maximum
pH @ 3% Concentration	4.7 to 7.0 pH
Water-holding Capacity	200% by weight on oven dry basis

The material shall readily blend with water, grass seed, fertilizer, and other additives to form a homogeneous slurry or mixture capable of application with power spray equipment. A colored dye that is noninjurious to plant growth and that fades rapidly with exposure to light may be used. Wood cellulose fiber shall be packaged in new, labeled containers in an air-dry condition.

(e) Sawdust. Sawdust shall be obtained from wood that has not been subjected to conditions that would cause the sawdust to lose its value or usefulness as a mulch. Sawdust shall not contain any toxic substances and shall be aged.

(f) Peat Moss. Peat moss shall be a granulated sphagnum peat moss nearly free of woody substances consisting of at least 75 percent of partially decomposed stems and leaves of sphagnum and essentially brown in color. The texture may vary from porous fibrous to spongy fibrous and shall be free of sticks, stones, and mineral matter. Peat moss shall be in an air-dry condition, show an acid reaction of 3.5 pH to 5.5 pH, and meet State and Federal regulations.

(g) Peat Humus. Peat humus shall be natural peat or peat humus from fresh water-saturated areas, consisting of sedge, sphagnum, or reed peat and be of a physical condition that will pass through a 1/2-inch mesh screen. The humus shall be free of sticks, stones, roots, and other objectionable materials. Samples taken at the source of supplies shall have the following characteristics when analyzed:

Acidity range	4.0 to 7.5 pH.
Minimum water absorbing ability	200 percent by weight on oven-dry basis
Minimum organic content	60 percent when dried at 105 °C

Freshly excavated peat, if saturated with water, shall be stored for a sufficient length of time to condition it for workability.

(h) Grass Straw Cellulose Fiber. Natural or cooked straw (grass processed to remove seed) cellulose fiber shall have the property of dispersing readily in water and shall have no toxic effect when combined with seed or other materials. The processed fiber shall contain no growth inhibiting factors or weed seed. The homogeneous slurry or mixture shall be capable of application with power spray equipment. A green colored dye that is noninjurious to plant growth may be used. The fiber shall be packaged in new, labeled containers, shall be of uniform weight (plus or minus 5 percent) in an air-dry condition, and shall bear the name of the manufacturer and the air-dry weight content. The fiber shall meet the following characteristics when tested:

Acidity range	6.5 - 7.5 pH
Moisture content (packaged fiber)	8 - 12%
Organic Matter	90.0 - 100.0%
Ash Content	0.0 - 10.0%

The contractor shall submit a Certificate of Compliance from the supplier that states their product meets all of the foregoing requirements, based on laboratory and field tests.

(i) Other. Mulch products made of other materials intended for this purpose shall be as specified in the SPECIAL PROJECT SPECIFICATIONS.

713.06 Plant Materials

(a) Quality of Plant Materials. All plants shall be first-class representatives of their normal species or varieties unless otherwise specified as "street-tree, "extra heavy," "clump," and other of like import, according to the particular exception. All plants shall be nursery-grown stock that has been transplanted or root-trimmed two or more times, according to the kind and size of plants. The branch system shall be of normal development and free of disfiguring knots, sun-scald, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements. Trees shall have reasonably straight stems and shall be well branched and symmetrical in accordance with their natural habits of growth.

(b) Plant Names. All scientific and common plant names and types specified shall meet the requirements in the edition of "Standardized Plant Names," as adopted by the American Joint Committee on Horticultural Nomenclature, that is in effect at the time of advertisement. All plants delivered shall be true to name and legibly tagged with the names and sizes of materials. Substitution of a plant or plants of a different variety than the plant material specified shall be subject to approval by the Engineer. An approved substitute plant shall be of a value at least equal to the respective specified plant.

(c) Grading Standards. Grading of plants shall meet the requirements of the "American Standard for Nursery Stock," as approved by the United States of America Standards Institute, in effect at the time of advertisement.

(d) Nursery Inspection and Plant Quarantine. All plants shall be free from plant diseases and insect pests. All shipments of plants shall comply with all nursery inspection and plant quarantine regulations of the States of origin and destination, as well as with Federal regulations governing interstate movement of nursery stock. A valid copy of the certificate of inspection shall accompany each package, box, bale, or carload.

(e) Balled and Burlapped Plants. Balled and burlapped plants shall be dug to retain as many fibrous roots as possible. The soil in the ball shall be the original and undisturbed soil in which the plant has been grown. The plant shall be dug, wrapped, transported, and handled so the soil in the ball will not be loosened and cause stripping of the small and fine feeding roots, or cause the soil to drop away from the roots.

713.07
Erosion Control Net & Blanket Material

All erosion control materials shall be made of new material, clean, sound, free of rips or tears, and furnished in lengths of at least 200 feet.

(a) Burlap. Burlap shall be of standard weave with a weight of 3.5 to 5.0 ounces per square yard.

(b) Jute Mesh. Jute mesh shall be of a uniform, plain weave with warp and weft yarns of approximately the same size. The physical requirements shall be:

(1) Width of 45 to 48 inches, plus or minus 1 inch.

(2) 78 warp ends per width.

(3) 41 weft ends per yard.

The weight of cloth shall average 1.80 pounds per running yard with a 5 percent minimum tolerance to an average of 1.22 pounds per running yard with a 5 percent minimum tolerance at standard atmospheric conditions.

(c) Woven Paper or Sisal Mesh Netting. Woven paper or woven sisal mesh netting shall be woven from twisted yarns available in rolls at least 45 inches wide. Mesh shall have a 3-inch by 3-inch maximum opening. Shrinkage after wetting shall not exceed 20 percent of the surface area. Netting shall have a minimum dry weight of 0.8 pound per square yard, plus or minus 10 percent.

(d) Excelsior Blanket. Excelsior blanket shall consist of a machine produced mat or curled wood excelsior of 80 percent 6-inch or longer fiber length with consistent thickness and the fiber evenly distributed over the entire area of the blanket. Fiber dimensions shall be 0.021 by 0.042 inch plus or minus 25 percent. Average weight per square yard to be 0.975 lbs. plus or minus 10 percent at time of manufacture.

(e) Photodegradable Plastic Mesh Netting. Material shall be extruded, retangular mesh and weigh approximately 3.0 pounds per 1,000 square feet, (plus 1/2 pound) and have a mesh opening and color as SHOWN ON THE DRAWINGS.

713.08 Miscellaneous

(a) Water. Water used in the planting or care of vegetation shall be free of oils, acids, alkalies, salts, or any substance injurious to plant life. Water sources shall be approved by the Engineer.

(b) Stakes for Bracing and Anchoring. Stakes for bracing or supporting trees shall be of wood, free of knots, rot, cross-grain, or other defects that would impair the strength of the stake. Stake size, length, and type shall be as SHOWN ON THE DRAWINGS.

(c) Ties. Tree ties shall be chain-type plastic green or black, approximately 1 inch wide and 1/8 inch thick; elastic belt webbing, 3/4 inch wide; or flexible tubing approximately 3/8 inch in diameter. Wire shall not be used as tree ties.

(d) Wrapping Material. Wrapping material for trees shall be an approved waterproof paper triple lamination 30-30-30 in 4-inch wide rolls, or an approved burlap in 6-inch wide rolls.

(e) Twine. Twine used for tying wrapping on trees shall be of approved quality. Two-ply twine shall be used for trees 3 inches and less in diameter, and three-ply twine for trees over 3 inches in diameter.

(f) Antidesiccant. Antidesiccant shall be an approved emulsion that will provide a film over plant surfaces permeable enough to permit transpiration. Antidesiccant shall be used only after approval by the Engineer.

(g) Tree Wound Dressing. Dressing for treating tree wounds or cuts shall be:

(1) An approved black asphaltum base antiseptic paint.

(2) An approved black paint consisting of Bordeaux mixture, raw linseed oil, and lampblack.

(3) An approved black paint consisting of zinc oxide, raw linseed oil, and lampblack.

(h) Staples. Staples shall be made of wire, 0.091 inch in diameter (11 gauge) or greater, "U" shaped with a 1 inch wide throat, and legs not less than 6 inches in length.

713.09 (Reserved)

713.10 Sod

Sod shall be living, vigorously growing, and predominantly of the grass and thickness specified in the SPECIAL PROJECT SPECIFICATIONS, having a dense root system contained in suitable sod and reasonably free from noxious weeds and grasses. When the sod is cut, its top growth shall not be more than 3 inches in height and it shall have a minimum of 1 inch of soil and root zone backing. Sod from other than commercial sources will be inspected by the Engineer at the source and shall not be cut prior to approval.

713
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713.11 Pegs for Sod

Pegs shall be of sound wood, at least 8 inches long, square or round and have a cross sectional area of approximately 1 square inch.

Section 715 - Piling

715.01 Untreated Timber Piles

Untreated timber piles shall meet the requirements of AASHTO M 168.

715.02 Treated Timber Piles

Treated timber piling shall be Douglas fir, larch, southern yellow pine, Norway pine, or red oak meeting the requirements of AASHTO M 168 and M 133. Preservative treatment shall be in accordance with Subsection 716.03.

One copy of the following Certificates of Compliance shall be furnished to the Engineer upon delivery of the piling to the work site:

(a) Supplier certification of species, and meeting the requirements of AASHTO M 168.

(b) Certificate of treatment, including type of treatment, retention (Assay Method), and penetration.

The compliance certifications shall be made by a qualified testing and inspection agency. The certification may be made by the supplier when the piling is stamped or branded with the American Wood Preservers Bureau (AWPB) quality mark.

715.03 (Reserved)

715.04 Steel Shells

(a) Shells Driven Without a Mandrel. Shells for cast-in-place concrete piles shall have a minimum 12-inch diameter at cutoff and a minimum 8-inch diameter tip; made from not less than 7-gauge (0.1792 inch in thickness) plate stock meeting the requirements of AASHTO M 183. Shells may be spirally welded or longitudinally welded and may be tapered or constant in section. Tips shall be sealed as SHOWN ON THE DRAWINGS.

(b) Shells Driven With a Mandrel. The shell shall be able to withstand driving without injury and resist harmful distortion or buckling due to soil pressure or the driving of adjacent piles after being driven and the mandrel removed. Butt and tip dimensions shall be as SHOWN ON THE DRAWINGS. The piles shall be water-tight to provide for placing of concrete in the dry.

715.05 Steel Pipes

(a) Filled Steel Pipe. Steel pipe to be driven as piles and filled with concrete shall meet the requirements of ASTM A 252, Grade 2. Closure plates for closed end piles shall meet the requirements of AASHTO M 183. Conical points shall be inside or outside flanged as SHOWN ON THE DRAWINGS; they shall be cast steel and taper at approximately 60 degrees; cast steel shall meet the requirements of ASTM 27 Grade 65/35.

(b) Unfilled Steel Pipe. Steel pipe for piles to be driven and not filled with concrete after driving shall meet the requirements of ASTM A 252, Grade 2, with chemical requirements meeting ASTM A 53, Grade B. Cast steel for open-end cutting shoes shall meet the requirements of ASTM A 148 Grade 90/60.

715.06 Steel H-Piles

Steel H-Piles shall be rolled steel sections of the weight and shape SHOWN ON THE DRAWINGS. They shall be structural steel meeting the requirements of AASHTO M 183. Copper-bearing structural steel shall contain not less than 0.20 percent nor more than 0.35 percent of copper. Steel manufactured by the acid-bessemer process shall not be used.

715.07 Sheet Piles

Steel sheet piles shall meet the requirements of AASHTO M 202 or M 223. All other sheet piles, except cold-formed lightweight steel sheeting, shall meet the requirements prescribed above.

Cold-formed lightweight steel sheeting shall be made from steel meeting the requirements of ASTM A 569 or A 526. The joints shall be practically water-tight when the piles are in place.

715.08
Pile Shoes

Pile shoes shall be as SHOWN ON THE DRAWINGS.

Section 716 - Material for Timber Structures

716.01 Structural Timber & Lumber

Structural timber and lumber shall meet the requirements of AASHTO M 168.

Lumber shall be of the kinds and grades SHOWN ON THE DRAWINGS. Round poles and posts shall be of the kinds SHOWN ON THE DRAWINGS.

716.02 Hardware & Structural Steel

Machine and carriage bolts, drift pins, and dowels shall meet the requirements of ASTM A 307. All hardware shall be galvanized in accordance with AASHTO M 232.

All structural steel shapes, rods, glued laminated deck panel dowels, and plates shall be structural steel meeting the requirements of AASHTO M 183. Galvanizing shall be in accordance with AASHTO M 111.

Bolts shall have square or hexagonal heads and nuts. Nails shall be cut or round nails of standard form. Spikes shall be cut, round, or boat, as SHOWN ON THE DRAWINGS.

Washers shall be malleable iron castings. Plain or cut washers shall be American Standard Plain Washers.

Ring or shear plate timber connectors shall be of approved design meeting the requirements of Article 2.20.1(f), AASHTO's "Standard Specifications for Highway Bridges."

716.03 Preservative Treatments

Timber preservatives and treatment methods shall meet the requirements of AASHTO M 133. The type of treatment to be used and minimum net retention of preservative will be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. All treated timber shall be completely and accurately fabricated before treatment. Except for Southern Pine, all surfaces greater than 2 inches in width, including glued laminated members, shall be incised before treatment. Glued laminated timbers shall be treated in accordance with AWPA C28.

Retentions of preservatives in all lumber and timbers, including laminates treated before gluing, shall be determined by the assay method.

716.04 Structural Glued Laminated Timber

(a) The fabrication and quality control of structural glued laminated timber shall be as SHOWN ON THE DRAWINGS and in accordance with the requirements of Voluntary Product Standard ANSI for "Structural Glued Laminated Timber" (ANSI-AITC-190-1).

(b) The members shall be manufactured as industrial appearance grade for wet use conditions, using a phenol-resorcinol resin-type adhesive throughout.

(c) Straight or slightly cambered members, which are to be loaded perpendicular to the wide face of the laminates, shall be stamped "top" on the top at both ends of the beam.

(d) (Reserved.)

(e) The following shall apply to fabrication of glued laminated deck panels in lieu of dimensional tolerances given in PS 56 (ANSI-AITC-190-1).

(1) Thickness (parallel to gluelines) . . . . . . ±1/16 inch.

(2) Width (perpendicular to gluelines) . ±1/8 inch per panel.

(3) Length . . . . ±1/8 inch.

(4) Squareness of cross section . . . . PS 56.

(5)	Crook	Maximum of 1/8 inch per 26-foot panel length for single crook. The sum of the maximum deviations shall not exceed this value for double crook.
(6)	Cup	Maximum of 1/32 inch per foot of width.

(f) Calking compound used to seal deck panel joints shall meet the requirements of Fed. Spec. TT-S-00230 or Fed. Spec. TT-S-001543 (com.) and shall be brown or bronze in color.

Section 717 - Structural Metal

717.01 Structural Steels

Structural steel shall meet the following requirements:

(a) General requirements for delivery of structural steel	AASHTO M 160
(b) Structural steel	AASHTO M 183
(c) (Reserved)	
(d) High-strength low-alloy structural steel	AASHTO M 161
(e) High-strength low-alloy structural manganese vanadium steel	AASHTO M 188
(f) (Reserved)	
(g) Mild steel arc-welding electrodes	AWS A 5.1
(h) High-strength, low-alloy columbium-vandium steels of structural quality	AASHTO M 223
(i) High-strength, low-alloy structural steel with 50,000 psi minimum yield point to 4 inch thick	AASHTO M 222
(j) High-yield-strength, quenched, and tempered alloy steel plate suitable for welding	AASHTO M 244
(k) General requirements for delivery of steel plates for pressure vessels	ASTM A 20
(l) Pressure vessel plates alloy steel, high-strength, quenched, and tempered	ASTM A 517
(m) Hot-formed welded and seamless high-strength low-alloy structural tubing	ASTM A 618
(n) Cold-formed welded and seamless carbon steel structural tubing in round and shapes	ASTM A 500 Grade B
(o) Hot-formed welded and seamless carbon steel structural tubing	ASTM A 501

717.02 Bolts & Nuts

Bolts and nuts shall meet the requirements of ASTM A 307, Grade A. Plain or cut washers shall be American Standard Plain Washers.

717.03 High-Tensile-Strength Bolts

High-strength bolts, nuts, and washers shall be in accordance with the "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts," as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation. All bolts, nuts, and washers shall be ASTM A 325, Type I.

717.04 (Reserved)

717.05 Forgings

Forgings shall meet the following requirements:

(a) Alloy steel forgings; Class A forgings shall be furnished unless otherwise specified	ASTM A 237
(b) Carbon steel forgings; Class C 1 forgings shall be furnished unless otherwise specified	AASHTO M 102

717.06
Pins & Rollers

Pins and rollers more than 9 inches in diameter shall be annealed, carbon steel forgings meeting the requirements of AASHTO M 102, Class C1.

Pins and rollers 9 inches or less in diameter shall be either annealed carbon-steel forgings meeting the requirements of AASHTO M 102, Class C1, or cold-finished carbon-steel shafting meeting the requirements of AASHTO M 169, Grade 1016 to 1030, inclusive, with a minimum Rockwell Scale B hardness of 85. Material not meeting the specification for hardness may be accepted, provided it develops a tensile strength of 70,000 psi and a yield point of 36,000 psi.

Threads for pins shall meet the requirements of the ANSI B1.1 Coarse Thread Series, Class 2A. Pin ends having a diameter of 1-3/8 inches or more shall be threaded six threads to the inch.

717.07
Castings

Castings shall meet the following requirements:

(a) Steel castings for highway bridges . . . . AASHTO M 192 Class 70

(b) Chromium alloy steel castings . . . . AASHTO M 163 (Grade CA 15 shall be furnished unless otherwise specified)

(c) Gray iron castings . . . . AASHTO M 105 Class 30

Iron castings shall be true to pattern in form and dimensions, free of pouring faults, sponginess, cracks, blow holes, and other defects in position affecting their strength and value for the service intended. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. All castings shall be cleaned of scale and sand to present a smooth, clean, and uniform surface.

(d) Malleable iron castings . . . . AASHTO M 106 Grade 35018

The requirements for workmanship, finishing, and cleaning shall be the same as for gray iron castings.

717.08
Steel Grid Floors

Steel for grid floors shall meet the requirements of AASHTO M 183 or M 222. Steel grid floors shall be weathering steel, galvanized or painted as SHOWN ON THE DRAWINGS. Floors other than weathering steel or galvanized material shall have a minimum copper content of 0.2 percent.

Open-type floors shall be galvanized.

717.09
Steel Pipe

Steel pipe shall meet the requirements of ASTM A 53, ASTM A 120, AASHTO M 222, or ASTM A 618 as SHOWN ON THE DRAWINGS.

Standard weight pipe shall be furnished.

717.10
Galvanized Metal

Galvanized structural steel shapes, plates, bars, strips, or their products shall be galvanized in accordance with the requirements of AASHTO M 111. Galvanized nuts, bolts, and hardware shall be galvanized in accordance with AASHTO M 232.

717.11
Sheet Lead

Sheet lead shall meet the requirements of AASHTO M 112 for common desilverized lead. The sheets shall be of uniform thickness and free from cracks, seams, slivers, scale, and other defects. Lead sheets shall be 1/8 inch in thickness with a permissible tolerance of 0.03 inch. Any holes or openings in the sheets shall be made by the sheet manufacturer.

717.12 Welded Stud Shear Connectors

(a) Shear connector studs shall meet the requirements of AASHTO M 169 for cold-finished, carbon-steel bars and shafting, and cold-drawn bar, Grade 1015, 1018, or 1020, semikilled or fully killed. If flux-retaining caps are used, the steel for the caps shall be of a low-carbon grade suitable for welding and shall be in accordance with ASTM A 109 for cold-rolled carbon-steel strip.

(b) Tensile properties, as determined by tests of bar stock after drawing or tests of finished studs shall meet the following requirements:

Tensile strength (minimum)	60,000 psi
Yield strength* (minimum)	50,000 psi
Elongation (minimum)	20 percent in 2 inches
Reduction in area (minimum)	50 percent

* As determined by the 0.2 percent offset method.

(c) Tensile properties shall be determined in accordance with applicable sections of ASTM A 370 for mechanical testing of steel products. Tensile tests of finished studs shall be made on studs welded to test plates using a test fixture with dimensions similar to those shown in Table 717-1.

If fracture occurs outside the middle half of the gauge length, the test shall be repeated.

(d) Finished studs shall be of uniform quality and condition, free of injurious laps, fins, seams, cracks, twists, bends or other injurious defects. The finish shall be produced by cold drawing, cold rolling, or machining.

(e) Studs shall meet the dimensions given in Table 717-1.

(f) The contractor shall furnish the manufacturer's certification that the studs delivered are in accordance with the requirements of this section. Certified copies of in-plant quality control test reports shall be furnished to the Engineer upon request.

Table 717-1.--Welded Stud Shear Connectors.

Standard Dimensions and Tolerances (Inches)			
Shank		Head	
Diameter	Length[a]	Diameter	Thickness
+0.0000 3/4 -0.0150	+0.062 4 -0.125	1-1/4 ± 1/64	3/8 minimum
+0.0000 7/8 -0.015	+0.062 4 -0.125	1-3/8 ± 1/64	3/8 minimum

[a] Length includes thickness of head.

717.13 Elastomeric Bearing Pads

Pads less than 1 inch in thickness shall be cast in a single integral layer. Pads 1 inch or more in thickness shall consist of alternate laminations of elastomer and metal or elastomer and fabric bonded together. The outside laminations shall be metal or fabric. The outside and edges of metal laminations shall be coated with elastomer not more than 1/8 inch in thickness. Laminations of elastomer shall be 1/2 inch ±1/8 inch in thickness. Variation in thickness of an individual elastomer lamination shall not exceed 1/8 inch, and the variation in thickness of all elastomer laminations shall not vary more than 1/8 inch from a plane parallel to the top or bottom surface of the pad. The total out-to-out thickness of the pad shall not be less than that SHOWN ON THE DRAWINGS and not more than 1/4 inch greater than that thickness. Variation in total thickness of any pad shall not exceed 1/8 inch. The length and width shall not vary more than 1/8 inch from the dimensions SHOWN ON THE DRAWINGS.

Pads containing metal laminations shall be full molded. Pads of all elastomer or with fabric laminations may be cut from large sheets. Cutting shall avoid heating of the material and produce a smooth edge with no tears or other jagged areas. If corners and edges of molded pads are rounded, the radius at the corners shall not exceed 3/8 inch and the edges shall not exceed 1/8 inch.

The bond between elastomer and metal or fabric shall fail within the elastomer when a sample is tested for separation.

Metal laminations shall be rolled mild steel sheets of not less than 0.0359 inch and not more than 0.0747 inch.

Fabric laminations shall be a long chain synthetic polymer containing at least 85 percent polyester from ethylene glycol and teraphthalic acid. Each ply of the fabric shall have a breaking strength of not less than 700 pounds per inch of width in both directions.

Fabric laminations shall be single ply at top and bottom surfaces of the pad and either double ply or double strength within the pad.

The rubber constituent of the elastomer shall be 100 percent (by volume) virgin chloroprene.

The elastomer, as determined from test specimens meeting the requirements of ASTM D 15, shall meet the requirements of Section 25, Division II, AASHTO's "Standard Specifications for Highway Bridges," for the durometer as SHOWN ON THE DRAWINGS.

Bearing pads may be approved, based upon written certification from the manufacturer that all components of the pads furnished meet the applicable requirements. The certification shall be supported by a certified copy of the tests performed upon components representative of those actually used in the pads furnished.

717.14 Structural Aluminum Alloy

Structural aluminum materials shall be as SHOWN ON THE DRAWINGS.

717.15 Materials for Aluminum Alloy Bridge Rail

Aluminum alloys SHOWN ON THE DRAWINGS shall meet the requirements of the specifications listed in table 717-2.

717.16 Aluminum Bolts & Nuts

Aluminum bolts and nuts shall meet the requirements of ANSI B18.2. Threads shall meet the requirements of American Standard coarse series, Class 2 fit, ANSI specification B1.1.

717.17 Aluminum Welding Wire

Aluminum welding wire shall meet the following requirements:

Alloys Series	Specification Wire	
3xxx and 6xxx	AWS 5.10	ER 4043
3xxx, 5xxx, and 6x	AWS 5.10	ER 5356
5xxx and 6xxx	AWS 5.10	ER 5556 or ER 5183

Table 717-2.--Aluminum alloys for bridge railing systems.

Railing Component	ASTM Material Specifications and Alloys								Aluminum Association Designation		
	Sheet and Plate B209	Drawn Seamless Tubes B210	Bars, Rods and Wire B211	Extruded Bars, Rods, Shapes, and Tubes B221	Seamless Pipe and Seamless Extruded Tubing B241	Welding Rods and Bars Electrodes B285	Standard Structural Shapes, Rolled or Extruded B308	Rivet Cold and Heading Wires and Rods B316	Sand Castings B26	Permanent Mold Castings B108	Former Casting Alloy Designation
Posts and Post Bases, Structural:											
Wrought				6061-T6 6063-T6	6061-T6 6063-T6		6061-T6				
Cast										A444.0-T4[e]	S7A-T4
Posts, Ornamental:											
Wrought				6061-T6 6063-T6	6061-T6 6063-T6					A356-T6	SG70A-T6
Cast									356.0-T6[b]	A356-T6	SG70B-T6
Rails & Sleeves, Structural:											
Wrought		6061-T6 6063-T6		6061-T6 6063-T6 6351-T5	6061-T6 6063-T6		6061-T6				
Bolts, Anchor[c]:											
Stainless Steel											
Galvanized Steel											
Aluminized Steel											
Bolts & Screws, Misc.[c d]:											
Aluminum, Wrought			2024-T4[e] 6061-T6[f]								
Stainless Steel											
Galvanized Steel											
Aluminized Steel											
Cadmium-plated Steel											
Nuts[g]:											
Wrought 1/4" and Under[d]			2024-T4 6061-T6 6262-T9	6061-T6[h]							
5/16" and Over											
Washers, Flat[g]											
Wrought	Alclad 2024-T4 Alclad 2024-T3[i]										

Table 717-2. (cont.)--Aluminum alloys for bridge railing systems.

	ASTM Material Specifications and Alloys								Aluminum Association Designation		
Railing Component	Sheet and Plate B209	Drawn Seamless Tubes B210	Bars, Rods and Wire B211	Extruded Bars, Rods, Shapes, and Tubes B221	Seamless Pipe and Seamless Extruded Tubing B241	Welding Rods and Bars Electrodes B285	Standard Structural Shapes, Rolled or Extruded B308	Rivet Cold and Heading Wires and Rods B316	Sand Castings B26	Permanent Mold Castings B108	Former Casting Alloy Designation
Washers, Springlock[g]: Wrought			7075-T6								
Rivets: Wrought				6061-T6[j]				6061-T6[k]			
Shims: Wrought	1100–0			6063-F[b]							
Cast									443.0-F		S5B-F
Weld Filler: Wrought						BR 3356					
End Caps: Wrought	6061-T6			6061-T6							
Cast									356.0-T6 356-F 443.0-F		SG70A-T6 SG70A-F S5B-F

General Note: "F" temper applies to products which acquire some temper from fabricating processes.

Specific Notes:

[a] AASHTO Designation M 193.

[b] Chemical composition only.

[c] Compatible stainless or coated steel nuts and washers shall be used. Aluminum not permitted for anchor bolts.

[d] Alloy 2024-T4 shall have an anodic coating of 0.00020" minimum thickness with dichromate or boiling water seal.

[e] Must be used for stress-carrying bolts and may be used for minor bolts.

[f] Permitted as an alternate material for minor bolts.

[g] For use with aluminum bolts and screws. Aluminum not permitted for anchor bolt nuts and washers.

[h] Recommended specification is B211 but 2221 acceptable as an alternate.

[i] In general, T4 temper is applicable to thickness of 1/4 inch and over, and T3 is applicable to lesser thicknesses.

[j] Recommended specification is B316, but B221 acceptable as an alternate.

[k] For rivets to be cold-driven.

[l] For rivets to be driven at temperatures of 990°F to 1050°F.

717.18 **Elastomeric Compression Joint Seals**	Elastomeric compression joint seals shall meet the requirments of AASHTO M 220.
717.19 **Metal Bin-Type Crib Walls**	The galvanized sheets shall meet the requirements of AASHTO M 218 as applicable. The metal type and thickness shall be as SHOWN ON THE DRAWINGS.

Section 718 - Sign Materials

718.01 Sign Panels

Sign panels shall be panels of one-piece construction made from plywood, sheet steel, or sheet aluminum, as shown in the SCHEDULE OF ITEMS, which have the face side reflectorized.

(a) Plywood Panels. The panels shall be exterior Type B-B, high-density overlay, 60/60 with black overlay on both sides, 3/4-inch 7 ply or 1/2-inch 5 ply thick, Douglas fir plywood or better, meeting the requirements of National Bureau of Standards PS 1, current edition or AS SHOWN ON THE DRAWINGS. Other overlay colors may be used provided the back of the panel is printed with two heavy coats of black paint.

(b) Aluminum Panels. All sheets and plates shall meet the requirements of ASTM B 209, alloy 6061-T6, or 5052-H38 and shall be of the thickness shown below unless otherwise SHOWN ON THE DRAWINGS.

Sign Width (Inches)	Sheet Aluminum Thickness (Inches)
Less than 8	0.022
8-12	0.040
13-19	0.063
20-30	0.080
31-48	0.100
over 48	0.125

718.02 Posts

Posts shall be wood, aluminum, steel, or other material as specified.

(a) Wood Posts. Wood posts shall meet the grading, species, and dimensional requirements SHOWN ON THE DRAWINGS and meet the treatment requirements of Subsection 716.03.

(b) Steel Posts. Steel posts shall meet the requirements of ASTM A 499, galvanized in accordance with AASHTO M 111. Minimum weight per foot will be as SHOWN ON THE DRAWINGS.

The posts shall have 7/16-inch holes drilled or punched, before galvanizing, along the centerline of the web. The punching or drilling should begin 1 inch from the top of the post, at 2-inch centers for the upper 5 feet of the post.

(c) Aluminum Posts. Aluminum posts shall be standard shapes as SHOWN ON THE DRAWINGS and shall be aluminum alloy 6061-T6 or 6351-T5 meeting the requirements of ASTM B 221.

718.03 Fittings

Lag screws, washers, clip angles, wood screws, shear plates, U-bolts, clamps, bolts, nuts, and other fasteners shall be galvanized steel, cadmium-plated steel, aluminum alloy, or as SHOWN ON THE DRAWINGS.

718
.01

Galvanizing of steel hardware shall be in accordance with AASHTO M 232. High-strength steel bolts, nuts, and washers shall meet the requirements of ASTM A 325, except as SHOWN ON THE DRAWINGS.

718.04 Reflective Materials Type II, & Type III Reflective Sheeting

All reflective materials (sheeting, legend, borders, and symbols) shall conform with the "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," FP, current edition and Federal Specification L-S-300C.

Colors shall be as specified in the MUTCD and enclosed drawings.

No more than 12 months shall elapse from the date of manufacture to the date of application on the substrate.

718.05
Letters, Numerals, Arrows, Symbols, Border

Letters, numerals, arrows, symbols, border, and other features of the sign message shall be of the type, size, and series SHOWN ON THE DRAWINGS.

Colors shall be as specified in MUTCD or SHOWN ON THE DRAWINGS. Completed letters, numerals, and other units shall be formed to provide continuous stroke width with smooth edges and shall present a flat surface free of warp, blisters, wrinkles, burrs, and splinters. Units of the sign message of the type SHOWN ON THE DRAWINGS shall meet the following requirements:

(a) Type L-1: Screen Process, Applied. The letters, numerals, arrows, symbols, and border shall be applied on the reflective sheeting or opaque background of the sign by direct or reverse screen process. Messages and borders of a color darker than the background shall be applied to the paint or the reflective sheeting by direct process. Message and borders of a color darker than sign field shall be produced by the reverse screen process.

Opaque or transparent colors, inks, and paints used in the screen process shall be of the type and quality recommended by the manufacturer of the reflective sheeting.

The screening shall be done in a manner that results in a uniform color and tone, with sharply defined edges of legend and border, and without blemishes on the sign background that will affect intended use.

After screening, signs shall be air dried or baked in accordance with manufacturer's recommendations to provide a smooth, hard finish. Any signs on which blisters appear during the drying process shall be rejected.

(b) Type L-3: Direct Applied Characters. The letters, numerals, symbols, border, and other features of the sign message shall be cut from Types II or III reflective sheeting of the color specified in MUTCD or SHOWN ON THE DRAWINGS and applied to the reflective sheeting of the sign field in accordance with the instructions of the manufacturer of reflective sheeting.

The reflective sheeting shall have minimum reflective intensity as specified in tables 718-3 or 718-4.

718.06
Delineators

The materials to be used for the delineator assembly shall be Type 1 or 2 as SHOWN ON THE DRAWINGS. The reflectors shall be amber or crystal and ready for mounting. Supporting posts shall be steel, aluminum, wood, or other material as SHOWN ON THE DRAWINGS.

Section 720 - Geotextiles

720.01
General

Geotextiles shall be woven or nonwoven fabric consisting of long-chain polymeric filaments such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene chloride formed into a stable network such that the filaments retain their relative position to each other. When SHOWN ON THE DRAWINGS or listed in table 720-1, the fabric shall contain stabilizers and/or inhibitors added to the base material to make the filaments resistant to deterioration due to ultraviolet or heat exposure. Fabric edges shall be selvaged or otherwise finished to prevent the outer material from pulling away from the fabric. The fabric shall conform to the physical strength requirements in table 720-1 for the appropriate function.

The contractor shall furnish the Engineer, in duplicate, a certificate signed by a legally authorized official from the contractor. The certificate shall attest that the geotextile meets the chemical, physical, and manufacturing requirements stated in this specification. When requested by the Engineer, or listed in table 720-1, a sample of 5 square yards of the geotextile shall be furnished from each shipment for verification testing. The sample shall be labeled with the lot and batch number, date of sampling, project number, specifications, manufacturer, and project name.

720.02
Delivery, Storage, & Handling

During shipment and storage, geotextiles shall be wrapped in a heavy duty protective covering. The geotextile shall be protected from mud, soil, dust, debris, and sunlight during transport and at the storage area.

720.03
Acceptance Test & Requirements

The properties will be determined in accordance with the test procedures in Subsection 720.07. Geotextiles for geotextile-reinforced retaining walls shall be pretested for Grab Tensile, 1 inch Cut Strip, and 8 inch Strip. The pretest results shall be provided to the Engineer prior to incorporating the geotextile reinforcement in the retaining wall. The geotextile function shall be as SHOWN ON THE DRAWINGS.

720.04
Securing Pins

Pins for securing the geotextiles shall be of steel, a minimum of 3/16 inch in diameter, and at least 15 inches in length. Each pin shall have one end capable of retaining a 1-1/2 inch diameter fender washer and the other end pointed. When necessary to secure the geotextile in place or when SHOWN ON THE DRAWINGS, the securing pin/washer assembly shall be driven through the geotextile until the fender washer is firmly against the geotextile and holding it securely in place.

720.05
Seams and Overlaps

The minimum overlaps at ends of rolls or between parallel rolls of fabric shall be SHOWN ON THE DRAWINGS but not less than the following:

Soil CBR	Minimum Overlaps
Greater than 2	1.5 feet
1 to 2	2 to 3 feet
0.5 to 1	3 feet or sewn
Less than 0.5	Sewn
All roll ends	3 feet or sewn

Fabric shall be staped or pinned at the overlaps to maintain them during construction activities. Spacing of pins shall be a minimum of 5 feet on centers for roll ends and as SHOWN ON THE DRAWINGS for parallel rolls.

Seams of sewn fabric shall be interlocking or sewn twice to provide a minimum of 70 percent of unseamed material.

720.06
(Reserved)

720.07
Test Methods

Test	Description
Grab Tensile ASTM D 1682	ASTM D 1682 Grab Test Method, using 1 square inch jaws and 12 inch per minute travel rate (five samples each in warp and in fill directions).
1-inch Cut Strip Test ASTM D 1682	ASTM D 1682 1-inch cut strip test using a specimen 1 inch wide by 6 inches long.
8-inch Strip Test	Use the ASTM D 1682 1-inch cut strip procedure with the following modifications: 1. Maintain minimum specimen width to gauge length ratio of 2 to 1 and minimum spacing between test grips of 4 inches (100 millimeter). 2. Test at constant strain rate of 10 percent per minute. 3. Test at standard laboratory conditions of 65 plus or minus 2 percent relative humidity and temperature of 70 °F plus or minus two degrees (21 °C plus or minus one degree). 4. Condition specimens by soaking for a minimum of 12 hours and test surface damp. 5. Use grips that do not weaken the specimen (disallow tests that fail at the grips) and which hold the geotextile without slippage. If slippage cannot be sufficiently limited, elongation must be measured between points on the specimen rather than between the grips. 6. Results should present the total unit load (applied force per unit width of specimen) versus strain curve as well as failure unit load and strain.
Bursting Strength (unaged fabric)(a)	ASTM D 751 Diaphragm Bursting Tester (five samples)
Puncture Strength (unaged fabric)(a)	ASTM D 751 Tension Testing Machine with ring clamp steel ball replaced with 5/16-inch diameter solid steel cylinder centered within ring clamp (five samples).
Abrasion Resistance	ASTM D 1682 Grab Tensile after abraded as required by ASTM D 1175 Rotary Platform, Double Head Method; rubber-base abrasive wheels equal to CS-17 "Calibrase" by Taber Instrument Co.; One kilogram load per wheel; 1,000 revolutions (five samples).
Percent Open Area	Each of five samples, unaged(a), shall be placed separately in 2-inch by 2-inch glass slide holder and the image projected with a slide projector on a screen. A block of 25 openings near the center of the image shall be selected and the length and width of each of the 25 openings and widths of the fibers adjacent to the openings shall be measured to the nearest 0.001 inch. The percent open area is determined by dividing the sum of the open areas of the 25 openings by the sum of the total area

of the 25 openings and their adjacent fibers.

Permeability Test

Either constant head or falling head permeameters similar to those conventionally used with soils may be used if the following factors are provided for:

1. Geotextiles characteristically have high permeability and small thickness. Therefore, resistance to flow through the fabric specimen is lowered to reduce errors. The permeameter and outlets must be designed, also, to offer very little resistance to flow, or head must be measured adjacent to both sides of the fabric.

2. The system must be deaired and deaired distilled water shall be used. Special care must be used to ensure removing all bubbles from the fabric. This may require presoaking some geotextiles.

(a) Unaged fabric is defined as fabric in the condition received from the manufacturer or distributor.

3. The fabric shall be supported across the orifice to prevent stretching.

4. Tests shall be run with head losses across a single geotextile specimen less than 12 inches (30 centimeters).

5. Results may be presented as either or both permeability or permittivity. To determine permeability requires the fabric thickness. The test shall be run at 70 °F plus or minus two degrees (20 °C plus or minus one degree) or temperature shall be measured and test results corrected to this temperature.

Thickness Test

Test Conditions. This test determines the perpendicular distance between a movable plane pressure plate and a reference plane separated by the geotextile in question. Any system capable of maintaining the plates parallel, maintaining the required pressure, determining the spacing, and satisfying the following considerations is satisfactory:

1. Minimum pressure foot area should be 3 square inches (20 square centimeters).

2. Test temperature to be 70 °F plus or minus two degrees (21 °C plus or minus one degree).

3. Specimens shall be conditioned by soaking for 12 hours minimum and tested surface damp.

4. The nominal thickness shall be measured with a pressure of 3.3 N/m^2 (0.07 psi). If thicknesses are desired at other pressures, the device shall allow for adding weights to provide these pressures.

Weight	ASTM D 1910, paragraph 37 or 38

DETERMINATION OF EQUIVALENT OPENING SIZE (EOS). Five unaged samples shall be tested according to Method A or B.

Method A. Sand Method. About 150 grams of each of the following fractions of a sand composed of sound rounded particles shall be obtained.

Designated EOS	U.S. Standard Sieve Number Passing	 Retained On	Designated EOS	Passing	Retained On
20	10	20	70	50	70
30	20	30	100	70	100
40	30	40	120	100	120
50	40	50			

The fabric shall be affixed to 8-inch diameter standard sieve having openings larger than the coarsest sand used. The cloth shall be attached so that no sand can pass between the cloth and the sieve wall. The sand shall be oven dried. Shaking shall be accomplished as described in ASTM D 422; and shall be continued for 20 minutes. Determine by sieving (using successively coarser fractions) that fraction of sand of which 5 percent or less by weight passes the cloth; the equivalent opening size of the cloth sample is the "retained on" U.S. Standard Sieve number of this fraction.

Method B. Glass Bead Method. About 50 grams of each of the following fraction of standard glass beads shall be obtained.

Designated EOS	U.S. Standard Sieve Number Passing	 Retained On	Designated EOS	Passing	Retained On
20	18	20	70	60	70
30	25	30	100	80	100
40	35	40			
50	45	50			

Within each size range, 98 percent of the beads should be within the specified range. The fabric shall be affixed to an 8-inch diameter standard sieve having openings larger than the largest beads to be used in the test. The fabric shall be attached to the sieve so that no beads can pass between the fabric and the sieve wall. Shaking shall be accomplished as described in ASTM D 422 and shall be continued for 20 minutes. Determine by sieving (using successively coarser fractions) that size of beads of which 5 percent or less by weight passes through the fabric; the equivalent opening size of the fabric sample is the "retained on" U.S. Standard Sieve number of this fraction.

Table 720-1.--Physical requirements.

Geotextile type [a,b] Function (Type)	1, 2, 3, 4 (A) Separation[d]	1, 2, 3, 4 (B) Normal[d] Stabilization	1, 2, 3, 4 (C) Heavy Duty[d] Stabilization	1, 2, 3, 4 (D) Silt Fence	3 (E) Light Riprap Drainage[c] (Low Abrasion)	3 (F) Heavy Riprap, Buttresses, and Gabions	1 (G) Reinforcement Retaining Walls	1, 2 (H) Pavement Reinforcement	(I) Erosion Control[h]
Sample Required							yes		
Ultraviolet Stabilization				yes	yes	yes	yes		
Grab Tensile, Lbs. ASTM D 1682	110 min	200 min	275 min	100 min	100 min	200 min	125 min[b]	90 min	
Grab Tensile elong. (%, ASTM D 1682)	15 min	15 min	15 min	15-40[f]	15 min	15 min	min	55 min	
Equiv. Opening size (LOS) US std sieve	20-100[g]	20-100	20-100		70-100[b]	70-100[b]			
1 in. Cut Strip Test, (Lbs.) ASTM D 1682							75 min[b]		
8 in. Strip Test, (Lbs.)							75 min[b]		
Bursting Strength, Unaged Fabric ASTM D 751	200 min	375 min	500 min	200 min	250 min	490 min			
Puncture Strength, Unaged Fabric ASTM D 751	42 min	80 min	100 min		60 min	120 min			
Abrasion Resistance (Lb.) ASTM D 1682					30 min	55 min			
% Open Area	9				4-10[b]	4-10[b]			
Permeability, cm/sec	0.001 min	0.001 min	0.001 min		0.01 min	0.01 min			
Weight, oz/yd^2	4 min	4 min	6 min	4 min	6.0 min	6.5 min	6 min		
Thickness, mils	15 min	15 min		10 min	10 min	10 min			
Shrinkage from Asphalt Texas DOT 3099								10% Max	
Absorbance gal/yd^2 Texas DOT 3099								0.2-0.3	
Retention Efficiency % VTM 51[e]				75 min					
Slurry Flow Rate g/m/ft^2 VTM 51[e]				0.3 min					

Table 720.1. (cont.)--Physical requirements.

[a] **Geotextile type:**

1 - Nonwoven needle punched.
2 - Nonwoven heat bonded.
3 - Woven monofilament.
4 - Woven slit film.

[b] Unless otherwise SHOWN ON THE DRAWINGS.

[c] To be used for riprap without wave action and cushioned from rock placement by a layer of sand or by zero drop height placement, in drainage trenches, and beneath concrete slabs (low abrasive uses).

[d] To be used where subgrade soils have properties as follows:

Separation - CBR greater than 3 or vane shear greater than 10 psi and/or particle size less than 2 inches.
Normal Stabilization - CBR between 1.5 and 3 or vane shear between 6 and 10 psi and/or particle size less than 4 inches.
Heavy Duty Stablization - CBR between 0.5 and 1.5 or vane shear between 2 psi and 6 psi and/or particle size less than 6 inches.

[e] Virginia DOT Test.

[f] Fabric and support system.

[g] Woven fabric with EOS between 20 and 70 shall have percent open area less than 4.0.

[h] As shown in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS.

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550 BRIDGE CONSTRUCTION

600 INCIDENTAL CONSTRUCTION

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